TECHNOLOGICAL CHANGE IN THE SALMON FARMING INDUSTRY IN CHILE: USING INVESTMENT DECISION TOOLS TO MODEL AN INNOVATION PATH AND A FRAMEWORK FOR DEVELOPING A NEW TECHNOLOGY

by

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ABSTRACT

Salmon farming is one of Chile's main economic activities, as well as a major factor in the country's aquaculture sector, and critical to the economic growth strategies proposed by the government. Chilean salmon farming is ranked number two in the world, competing closely with Norway (number one), mainly because of Chile's sophisticated global markets. However, to maintain sustainable growth and competitiveness, innovations and technological changes are needed in the industry.

I modeled the salmon industry in Chile using investment decision tools to determine the best innovation path. I also analyzed new technology that could be used to define a framework for development. The innovation path was identified by modeling a production company and applying sensitivity analysis to determine key variables. The innovation path has two parts focused on production cost: in the short term, reducing production cost for managing nets in the seawater phase; and in the long term, focusing on food items, smolts, and fish growth rates.

Following the analysis, I conducted a case study of a new technology called the washing *in situ* system (WISS), which makes changes to the net management system for the entire fish production while reducing costs and improving the productive and sanitary conditions. In the model, the market price for utilizing the WISS technology was set at $467 per cage per month, a 15% reduction compared with the traditional system, and equivalent to $191 thousand dollar per center with a production cycle of 18 months. The maximum investment was $44 thousand dollar per production center, to generate a profit of 30%. I also calculated the tradeoff between cost and investment, set at -5.44, which helped define the direction of the development path for the proposed new solution.

The methodology and models developed are powerful tools that can be used to define the best innovation path and provide a framework for developing a new technology solution that can be applied to the salmon farming industry in Chile.

Valuable data was obtained as an outcome of this study, which could be used to guide innovation efforts for implementing the WISS solution throughout the aquaculture industry.

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To Marlene, who brings me the best of this world – her love and happiness.

To my Father and Mother, who taught me the value of excellence and enjoying life.

Carlos Lonza
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BIOGRAPHICAL INFORMATION

Carlos Lonza is from Chile. He holds an MBA and B.E. in Aquaculture, and a B.A. in Management from the Universidad de Chile, where he graduated with highest honors. Currently he is a candidate for an Master of Science in Management of Technology at MIT.

Carlos has worked for more than 15 years in innovative and productive projects related to the aquaculture, agriculture, and forestry sectors in Chile. He has a solid technical background with strong finance and management skills in start-ups, project implementation, and investment decision making.

His current task is to attend MIT where plans to acquire management R&D skills and to transfer technology to the aquaculture sector in Chile. His specialization at MIT is focused on entrepreneurship, innovation, and leadership.

Table of Contents

Chapter 1. Introduction 6
Chapter 2. Overview of the Salmon Farming Industry and Innovations 9
Chapter 3. Theory Framework and Methodology 13
Chapter 4. Innovation Path and Modeling with Investment Decisions Tools 15
4.1. Modeling the Salmon Farming Industry in Chile 16
4.2. Critical Industry Variables 19
4.3. Innovation Path 21
Chapter 5. Case Study: A New Production Technology 22
5.1. Modeling the Case Study 23
5.2 Developing a Path for the New Technology 26
Chapter 6. Results and Discussion 29
6.1 Innovation Path Derived From the Models 30
6.2 Case Study Results: Defining an Innovation Path 31
6.3 Competitive Tariff and Goals in the Developing New Technology 32
6.4 Tradeoff Between Investment and Cost: Its Effect on Developing the Path for a New Technology 34
Chapter 7. Practical Application, Next Steps, and Recommendations 38
Chapter 8. Conclusion 40
Annexes 43
References 73

Chapter 1. Introduction

Chile is an open market-oriented economy that pursues an export-oriented growth strategy (34% of the GDP comes from exports). Chile was the first country in South America to join the Organization for Economic Cooperation and Development (OECD); in recent years its GDP expanded from $4,500 per capita to $15,400, demonstrating Chile's economic success. The country's GDP is in the upper middle of the economic ladder, leading South America in economic terms (World Bank, 2011); it is ranked number 30 as the most competitive country in the world and first in Latin America (World Economic Forum, 2009).

Chile's current goal is to achieve higher income status by 2018. It is on track to reach that goal while climbing up the value chain toward becoming a developed country with high standard of living. However, it must also work to improve its global competitiveness through productivity increases, further education for its skilled workers, development of industry clusters, and promoting technological change and innovation. Chile needs to consolidate these factors in order to obtain a sustainable competitive advantage for the long term.

To meet these challenges, the government has created the National Innovation Council for Competitiveness of Chile (CNIC), a public-private organization established as a permanent advisory to the president on issues of policies relative to innovation and competitiveness, including the development of science and technology, formation of advanced human capital, and innovative entrepreneurship, as well as acting as a catalyst in key initiatives in these areas (CNIC, 2011).

In 2006 CNIC asked The Boston Consulting Group (BCG) to identify the economic sectors with the greatest potential for growth in the Chilean economy. The results of the study, completed in 2007, identified aquaculture as one of 11 sectors that would contribute significantly to an increase in the GDP by 2021. CNIC identified this sector among eight priority areas in its strategy proposal. Within this sector, the salmon farming industry is the major activity, with great impact on diversification of exports and impact on the economy of extreme southern Chile.

The Chilean salmon farming industry is ranked number two in the world and competes globally against Norway (ranked number 1) for the U.S. and Japanese markets, both of which are large consumers of salmon. The main competitive advantages for Chile are its clean water, protected bays, favorable water temperatures, and broad experience in fisheries and fish farming. However, the product is now becoming commoditized, and it has been negatively impacted by the recent global recession and by a sanitary crisis in the industry in 2007. These factors have increased pressure on the industry to identify and implement innovations and new technologies as a fundamental requirement for increasing productivity and competitiveness in the long run, driving sustainable growth, and finding new steps forward for the salmon farming industry of Chile.

This thesis addresses the issues of innovation and new technologies in salmon farming in Chile by using investing decisions tools as a framework for building industry models and defining an innovation path. The innovation path is key because it identifies where efforts of innovation should be focused in order to obtain a sustainable path of growth, profitability, competiveness, and technological changes. It also suggests a framework for developing a new technology; identifies goals for competitive market prices, operations costs, and investments to achieve desired profitability; as well as realistic time to market for the new technology.

Objectives:

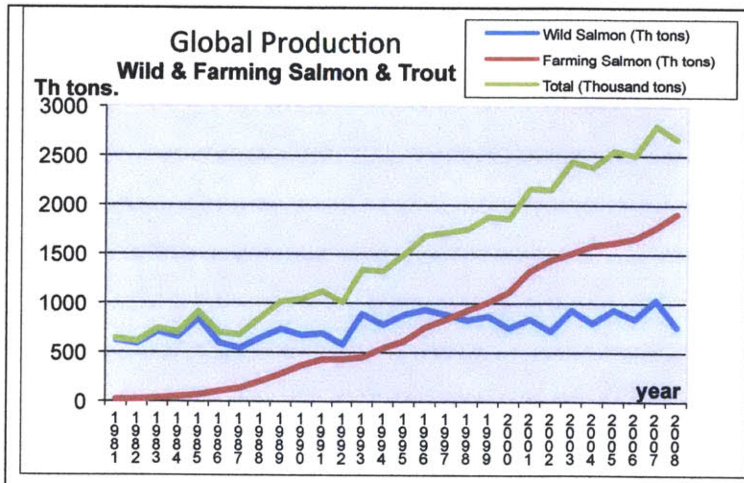
- Model the salmon farming industry in Chile using investment decision tools.
- Identify critical industry variables to define a recommended innovation path.
- Use a case study to align with the identified innovation path.
- Identify goals for developing the new technology proposal considering competitive price to market, cost of operations, investment, and profitability.
- Define the development path of the new technology, taking into consideration the tradeoffs between operating cost and investment needed to achieve a desired profitability.
- Define a practical application and the next steps required to develop and implement the technology proposal.

- Provide a framework and recommendations for future technological changes in the industry.

The thesis is divided in eight chapters, beginning with an overview of the salmon farming industry, followed by a review of the financial concepts supporting the modeling and investment decisions tools applied. Then follows the modeling of the industry using an average production company as a case study and analyzing it to determine critical variables and a recommended innovation path. The new technology is modeled to align with the innovation path proposal as a case study. Then follows results and discussion of the models, a practical application, and next steps for implementing the new technology proposal, I end with recommendations and conclusions.

Chapter 2. Overview of the Salmon Farming Industry and Innovations

The global production of salmon and trout reached 2.67 million tons in 2008, with a value of more than US$10 billion. This production includes wild captures of 761,000 tons and farming production of 1.9 million tons in 2008. Figure 2.1 shows global salmon production, both wild and farmed. Note that wild production has remained around 750,000 tons per year, and with a negative growth rate of -0.84% per year in the last decade. Salmon farming represents 71% of total fish production; this number has grown an average of 19% per year since 1981, and it is expected to continue (see Annex 2.1).



Source: Elaborated based on statistics from Aqua.cl and SalmonChile.cl, 2012.

Fig. 2.1 Global Production: Wild & Farmed Salmon and Trout

Table 2.1 shows salmon farming production by country.

Table 2.1. Salmon Farming Production by country, growth rates and projections

Country	2008	% part	% Growth 1998-2008	2012e	2020e	% Projected Growth
Norway	839	44%	8.0%	908	1064	2.0%
Chile	657	34%	9.8%	799	1180	5.0%
UK	137	7%	3.2%	142	153	0.9%
Canada	126	7%	10.4%	142	180	3.0%
Others	148	8%	0.92%	148	148	0.0%
Total	1907	100%	7.48%	2139	2724	3.0%

Source: Elaborated based on statistics from Aqua.cl and SalmonChile.cl, 2012.

The salmon farming industry is the main economic activity in extreme southern Chile, with more than US$2,200 million in exports per year, representing 93.1% of total national aquaculture production. The industry was developed in the early 1980s, with serious investment in the 1990s, and a sustained annual growth rate of 18% for more than 16 years (SalmonChile web site, 2012; Aqua website, 2012; CNIC, 2009). This spectacular development is expected to continue due to increased demand for aquaculture products due to increase of world population; limited increase in the volume of fisheries with decreasing captures each year; a positive correlation between consumption of fish and trends toward healthy food. The major market for Chilean salmon is Japan, with 44% of sales, followed by the U.S. with 16%, and Latin America with 16% in 2010. Prices range between US$4.44 to $8.16 per kilogram. Annex 2.3 details the quantity of salmon exported from Chile, its value, growth rates, and trends.

Salmon farming includes the production of Atlantic salmon (*Salmo Salar*), Pacific salmon (*Oncorhynchus kisutch*), and Trout (*Oncorhynchus mykiss*) with 26%, 24%, and 36% of total production in 2010, respectively (Annex 2.4). Within overall production, 63% is frozen for commercial sale, and 18% remains fresh (Annex 2.5). In 2008, Atlantic salmon represented 43% of total biomass and 60% of industry revenues—a figures that changed in 2010 due to a sanitation crisis. But, in the future, it is expected that the figures will return again to Atlantic salmon as favorites.

The production cycle typically consist of two stages: (1) six to twelve months in sweet water to obtain the salmon eggs, then the juveniles, and finally the smolts (Annex 2.6), which are then transferred to (2) the second stage in saltwater for 12 to 14 months to grow and fatten the fish. The production of biomass is in tanks in its phase of sweet water and flotation platforms in the ocean in semi-protected sites in its phase of fattening. Annexes 2.7, 2.8, and 2.9 contain photographs of the production cycle and equipment used in the salmon industry in Chile.

Chile produces more than 600,000 tons of salmon per year. There are 30 production companies and more than 200 supplier companies which generate more than 35,000 direct jobs and 25,000 indirect jobs. The industry is organized in clusters, developing related and supporting companies, professional carriers, and technological centers for creation and adaptation of technology and its transfer to the industrial sector. These represent one source of the industry's competitiveness, making it difficult for rivals to emulate and create a competitive advantage.

Growth opportunities in Chile are enormous, considering that demand is growing, Chile is politically stable, and property protection policies are in place. The industry uses only 20% of available area for aquaculture; it has an excellent quantity and quality of sweet water for the production of eggs and smolts; and plenty of saltwater for fattening the fish, which is the final step in the production cycle. It is expected that by 2015 shipments to exterior markets and new investment and player configurations will double. In fact, new investment has increased to US$380 million, thereby increasing capacity by 150,000 tons each year.

Despite these positive trends, the sector has endured negative influences as well: labor problems, environmental issues, and questions of sustainability—the latter triggered by the sanitation shock that occurred in June 2007 which infected the production centers with the Infectious Salmon Anemia (ISA). SERNAPESCA, Chile's National Fisheries Service, found 112 production centers with the disease, and 87 more centers at risk of becoming contaminated. In 2007, a total of 735 centers were infected, amounting to 25% of the productive areas. The disease generated high mortality rates specifically among the Atlantic Salmon, which represented 43% of total production in 2008 (Annex 2.4). This, in turn, caused serious economic and social effects, with more than $800 million in losses, thousand of workers fired, and a general deterioration of the economy in the region.

The crisis also uncovered numerous problems, including coordination failures, the agglomeration of productions center in specific areas, indiscriminate transportation of biological material, risky management of eggs and reproductive fish, excessive increases in the density of culture, and poor environmental management. The crisis also increased with the commoditization of the product, financial distress in the upper-income economies, and the global recession. This has caused the private and public sectors in Chile to rethink the strategies for developing the salmon farming industry, including increasing productivity and developing sustainable competitiveness. It became clear that the industry needs to generate solutions and establish bases for redefined the industry with high sanitary and sustainability standards, especially recognizing its dominance in the aquaculture sector and its key importance to the economy and development of isolated regions.

These solutions will be lead by innovations and new technologies in the industrial sector, in turn supporting Chile's goal to bring the salmon farming industry to a global leadership level within a few years. Chile is not yet at the productive frontier, so there is much room improving knowledge, training skilled workers, developing innovations in the value chain, and identifying new technologies. All of these will push productivity, enabling Chile to take a position as a global leader in the industry.

Chapter 3. Theory Framework and Methodology

All business activities can be reduced to two functions: valuation of assets and management of assets. Technological change involves these two functions; on one hand new technology needs to be evaluated to determine if it is suitable for the business goals, growth, and sustainability; on the other hand, consideration must be given to implementation, operation, and management, and how the new technology can create value for the business and its customers.

Valuation is the starting point; once value is established, management becomes easier. Starting with the objectives of the business, then adding in valuation, it becomes possible to make decisions.

In the salmon farming industry, the objective is to become more sustainable and competitive in global markets through innovations and technological changes. Consequently, it is necessary to evaluate possible innovations and changes to decide whether or not to implement them. Technological change implies a sequence of cash flow for the firm as investment, operating costs, and hopefully incremental revenues. So when evaluating, it is possible to apply a theory for valuing assets where the sequence of cash flows are the basic building blocks, and the Present Value (PV) of these cash flows is critical to making better decisions.

The concept of Net Present Value (NPV) is one of the more important ideas in finance, and it can be used for evaluating technological change in the industry. NPV is the Present Value of all cash flows from the assets or projects that occur on different dates in the timeline. Cash flow at date zero is the initial investment or capital expenditure (CAPEX) required for starting a company or implementing a new technology. Cash flows are discounted using an appropriate discount rate that considerers opportunity costs and project risks using CAPM method. NPV delivers the valuation by date zero of a new project or investment, taking into consideration all its cash flow from the timeline, as well as risk and opportunity cost.

So the performance of two or more assets can be compared using NPV, which enables us to decide the best option—in our case, technological change. In finance this framework is called Capital Budgeting. The objective is to increase the firm's current market value, which implies that current projects must have a positive NPV.

Technological change implies mutually exclusive (alternative) projects, that is, one can choose only one alternative, not both. In this case, the options are (1) a traditional system in the salmon farming industry, or (2) the new technology proposal. In either case, one must take the option with the highest and positive NPV. If two alternatives have the same output measure, for example, in revenues, it is not necessary to model all the cash flow for revenues because they are identical. So valuation can be done using the PV of project expenses, that is, the cash flow for investments and operating costs.

Considering the framework described above, the methodology I use is to model the industry through building its cash flow and obtaining the NPV for an average company. Then sensitivity analysis was applied to the cash flow model, based on NPV output to identify the variables and their impact on salmon farming in the industry—and therefore on its performance. The variables with more impact on the NPV are good indicators of the technological path to be recommended.

Once the technological path was identified, it became the best case study available for modeling technological change in the industry. It was possible to build the cash flows of the new technology proposal and compare them with the traditional system, enabling me to identify investment limits, operational costs, and market price to be adopted for the industry, and the framework for its development. Specific details about the financial methods, assumptions, and orientation of the solution are discussed in the following chapters.

Chapter 4. Innovation Path: Modeling with Investment Decisions Tools

The technological changes and innovations needed to generate solutions in the Chilean salmon farming industry must focus on improving industry competitiveness and sustainability in order to overcome problems such as sanitary crises and future challenges.

Current problems as well as future challenges share a common factor: Pressure to reduce costs. Because of fierce global competition and the structure of the industry, customers have enormous bargaining power. Commoditization of the industry´s products and the competitive forces in the market have caused companies to seek out a position of cost leadership. Demand is elastic, especially with such a commoditized product, so any cost reductions that can be used to lower prices will mean an increase in market share that is greater than losses incurred because of reduced prices. Consequently, companies that seek to increase their revenues and profits must also reduce the market price of their products, which makes the focus on production costs even more imperative. Therefore, the Chilean salmon farming industry must compete by reducing costs.

Cost reductions can be obtained through reducing the amount of fixed costs, variable costs, increasing biomass per production unit (productivity), or some combination of the three. Investments play a role as well through the cost of the capital. The obvious question is: Which of these variables should be the focus of the industry's efforts? Which variable has the most impact?

As said, one way to answer these questions is to model Chilean salmon farming using investment decision tools. This includes building cash flow estimates, applying sensitivity analysis, identifying performance indicators for analysis, and obtaining answers about the correct target of innovation efforts. After modeling, it is possible to identify an innovation path that will enable the industry to achieve a competitive position.

4.1. Modeling the Salmon Farming Industry in Chile

Modeling began by building a cash flow for a production cycle that incorporated all outflows and inflows for investment, cost, and revenues for biomass production. It applied a discount rate of 20%, which is appropriate for the aquaculture industry in Chile, and a valuation criteria of Net Present Value (NPV). Annex 4.1 a) y b) details the calculations and the calculus of the discount rate for fish farming in Chile using CAPM method.

Table 4.1 summarizes the calculation memory used in modeling salmon farming in Chile. It is based on the Atlantic Salmon (*Salmo salar*) species, the primary species being farmed, which, as noted, accounts for 43% of harvested biomass in Chile and 60% of revenues at 2008. The study unit was one production center (the basic unit of production), and the results are representative of the industry in general.

Table 4.1. Calculation memory for modeling the salmon farming industry.

Evaluation Level :	Prefeasibility
Species :	*Atlantic Salmon (Salmo salar)*
Unit of study :	One Center of Production
Period considered :	Fatness (ocean cycle)
Evaluation Horizon :	18 months
Harvest Density :	15 kg/m3
Evaluation Criteria :	Net Present Value
Annual Discount Rate :	20%
Equivalent Monthly Discount Rate :	1.88%
Current Company Tax rate :	17%

Source: own elaboration, 2012

My analysis focuses on the ocean production system, taking an evaluation horizon of 18 months and a harvesting density of 15 kg/m^3, which is the limit recommended by the Chilean fisheries authorities. I focused in the seawater phase because its largest investment and cost necessary in this phase, which has a high impact on final production costs, and ultimately, on industry competitiveness.

The model is based on a production cycle in the ocean phase that starts with planting one million fish of 100 grams in each production center. After 18 months, it is possible to harvest fish of 5,000 grams with an accumulative mortality rate of 20% per cycle, meaning 4,000 tons per center per production cycle as biomass harvested (Table 4.2.). Note that this biomass meets the limit of density of 15 kg/m^3 in each production system. Table 4.3 provides details of the economic parameters, including price, cost, and investment for one production center that realizes 4,000 tons as biomass harvested.

Table 4.2. Production parameters considered in the salmon farming industry model

Weight start fattening fish (Wi) (gr.) :	100 gr.
Weight harvested fish (Wf) (gr.) :	5,000 gr.
Fattening period (months) :	18 m
Equivalent growth rate (SGR%) :	0.71%
Accumulative Mortality x cycle :	20.0%
Equivalent monthly mortality :	1.23%
Fish planted number x center :	1,000,000
Fish harvested number x center :	800,000
Harvesting biomass (ton x center) :	4,000 ton

Source: own elaboration, 2012

Table 4.3. Economic parameters considered in modeling the salmon farming industry

Revenues	Sales Price ($ x kg):	US$ 5.5/ kg
Cost	Production Cost ($ x kg) :	US$ 2.8/ kg
	Plant & Distribution Cost ($ x kg) :	US$ 0.8/ kg
	Allocation production cost :	Proportional fattening period
CAPEX	CAPEX in Production Center (K$) :	$ 1,800
	CAPEX Nominal Assets (% over Fixed Assets) :	10%
No Cash Expenses	Useful life Fixed Assets (years) :	3
	Useful life Nominal Assets (years) :	5
Terminal Value	Real useful life Fixed Assets (months) :	96
	Salvage Value (K$) :	K$ 1,463
	Working capital (all month 0) (K$) :	K$ 10,578
	Book Value (K$) :	K$ 12,040

Source: own elaboration, 2012

Cash flow for the salmon farming industry is detailed in Table 4.4 and was based on the parameters mentioned above. The full cash flow is detailed in Annex 4.2.

Table 4.4. Cash flows for the salmon farming industry model

Items/ months	**0**	**1**	**2 to 17**	**18**
Sales Price ($/kg) :		$ 5.5	$ 5.5	$ 5.5
Output (ton.) :		0	0	4,000
Total Revenues (K$) :		**0**	**0**	**22,000**
Production Costs (K$) :		-622	-622	-622
Plant & Distribution Costs (K$) :		0	0	-3,200
- (Depreciation + Amort.) (K$) :		-53	-53	-53
EBT (K$) :		**-675**	**-675**	**18,125**
TAX (17%) (K$) :		0	0	-1,130
EAT (K$) :		**-675**	**-675**	**16,995**
+ (Depreciation + Amort.) (K$) :		53	53	53
CAPEX Fix Assets (K$) :	-1,800			
CAPEX Nominal Assets (K$) :	-180			
Working Capital (K$) :	-10,578			
Terminal Value (K$) :		0	0	12,040
CASH FLOW (K$) :	**-12,558**	**-622**	**-622**	**29,088**
Accumulated Cash Flow (K$) :	-12,558	-13,180	-13,802	5,953

Source: own elaboration, 2012

The model shows that salmon farming in Chile has a positive NPV of K$319, with a discount rate of 20% annually (Table 4.5). Figure 4.2 illustrates the cash flows and costs over an 18-month period. The project IRR is 21.5% superior to the discount rate, supports a positive NPV, and therefore creates value. The complete calculation for determining working capital is detailed in Annex 4.3.

Table 4.5. Performance Indicators of the model

NPV (20%) K$:	$ 319
IRR% (annual) :	21.47%
Accumulated cash flow (K$) :	$ 5,953
Average operating cost (K$/month) :	$ 800

Startup & CAPEX (K$) :	$ 1,980
Working Capital (K$) :	$ 10,578
Terminal value (K$) :	$ 12,040

Source: own elaboration based on the result of the evaluation, 2012

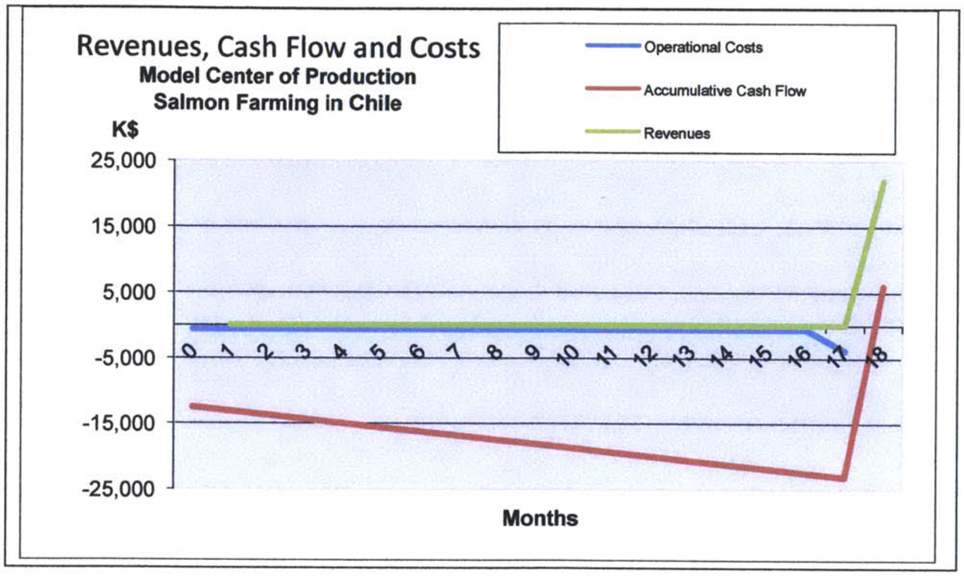


Fig. 4.2 Cash flows and costs

4.2 Critical Industry Variables

The critical variables are defined by their impact on performance indicators in the model, in this case an NPV(20%). The impact of each variable was measured by applying a sensitivity analysis to the cash flow and then registering the NPV in each case. A change was applied in each variable in the study, and then measured how it affected the model's NPV. If a small change in one variable produced a large change in the NPV, this variable was considered critical as a factor that would define the focus for innovation efforts in the industry. Moreover, after obtaining the results, it was possible rank the critical variables in the model.

The main results of the sensitivity analysis are shown in Table 4.6, with further details provided in Annex 4.4. The analysis tested changes in the biomass, fattening period, mortality, sales price, production costs, plant & distributions costs, and CAPEX. Three variables were found to have the most impact on the NPV of the model: sales price, production costs, and distributions costs—first, second, and third in the impact ranking, respectively.

Table 4.6 Results of the sensitivity analysis

Variables to Sensitize	Unit	Initial Value	dNPV/dx (1%)	Impact Ranking
Biomass :	Ton.	4,000 tons	3.47%	4
Fattening period :	Month	18 months	0.03%	7
Accumulate Mortality :	%	20.0%	-0.92%	6
Sales Price :	$ x kilo	$ 5.5	43.61%	1
Production Costs :	$ x kilo	$ 2.80	-33.84%	2
Plant & Distribution Costs :	$ x kilo	$ 0.80	-6.25%	3
CAPEX :	K$	$ 1,980	-2.80%	5

Source: own elaboration based on the results of the sensitivity analysis

The third column in Table 4.6 (dNPV/dx) shows the change in the NPV when the variable (sales prices, costs, etc.) is changed by 1%. For instance, the NPV decreased by -33.84% when production costs rose 1%. (Annex 4.4 details the results of the sensitivity analysis.).

Figure 4.3 illustrates the relation between percentage changes in each variable and the amount of change in the model's NPV. Curves with more slope represent the variables that had greater impact on the NPV of the project, i.e., sales price, and production cost.

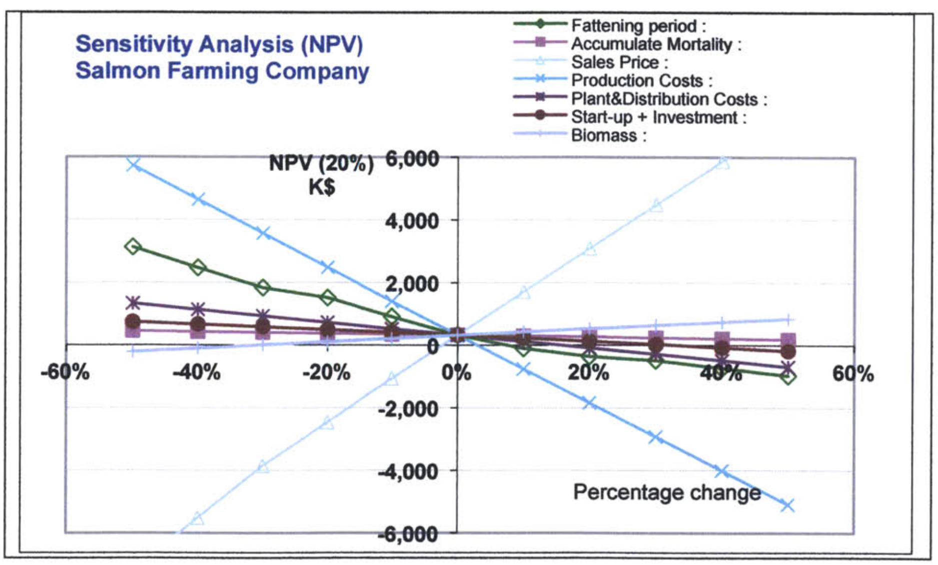


Fig. 4.3 Sensitivity analysis of a salmon farming company

4.3 Innovation Path

Innovation efforts should be directed to those variables that have the most impact on the performance of salmon farming. The analysis above showed that sales price and costs of production have the greatest impact, but the salmon market is an open market with a competitive structure, so price is fixed by the market, and the industry cannot influence it; hence the effort of any innovation should be directed to the cost of production.

Table 4.7 shows the factors that comprise production cost. Food, smolts, and management of nets are the more relevant costs in salmon production, representing 57%, 18%, and 11% of total production costs ($2.8/kg), respectively. So innovation efforts should be directed primarily at these three items.

Table 4.7. Production cost structure of the industry

Item	Structure (%)	$ per kg.
Food	57%	1.60
Smolts	18%	0.50
Management of Nets	11%	0.31
Operations issues	8%	0.22
Sanitary issues	4%	0.11
HR	2%	0.06
	100%	2.80

Source: own elaboration based on available information in the industry, 2012

Innovations in salmon food, the feeding system, and smolts are possible but are long term variables because they would require huge investments in R&D and new production facilities. However, in the case of net management, it is possible to introduce innovations in the short-term and with less required capital. Therefore, the innovation path should focus first (short-term) in reducing the cost of production for managing the nets of the culture system during the seawater phase, when biomass is growing and fish fattening have the greatest impact on business performance.

Chapter 5. Case Study: A New Production Technology

As identified in the innovation path, the short-term focus should first be on reducing the cost of production for managing the nets of the culture system during the fattening phase in seawater. This focus makes sense given – as noted - that the salmon market is an open and highly competitive market, and that the product is becoming commoditized. Both factors push companies to take a cost leadership position in reducing the market price of the product, increasing market share, and improving profits.

The system for cultivating salmon in ocean water utilizes floating cages surrounded by nylon nets. The nets accumulate marine micro- and macro-organisms that can foul the water and hamper the flow of water through the cages, creating low levels of oxygen and poor sanitary and production conditions for the fish. Nets around the cages currently must be constantly changed and sent to special facilities on land to maintain and restore them at an associated high cost. Traditionally, net-managing services has been provided by suppliers companies, leaving the productive company with focus in the core of the salmon business.

The industry in Chile is discussing the development of two solutions for net managing: copper net system (CNS), and a washing in situ system (WISS). The CNS system consists of a rigid, solid cage made of copper, which largely prevents fouling, thereby reducing the need for net changes and reducing costs. The WISS system works by cleaning the nets regularly on site using a special device that avoids fouling and requires fewer changes (further described in Annex 5.1).

The WISS system has more advantages than the CNS solution. With WISS, it is possible to implement service from supplier companies with a moderate investment because there are no important patents or other barriers to entrance; in the case of the CNS solution, the material used in the cages is patented by a Japanese company. Moreover, the salmon companies have built a strong supply chain related to managing the nets, so adoption of the WISS technology through a service company seems to be the easier solution and it will be align with traditional way to operate in the industry. For this reason, the WISS solution has greater potential for success, so the case study proposes use of the WISS solution.

5.1 Modeling the Case Study

The case study modeled and analyzed the WISS solution as a technological alternative to the traditional net managing system. Modeling was performed through economic analysis based on the Cost Present Value (CPV) of each system considering the incremental costs when both are compared. Based on CPV of the traditional system, it was possible to obtain the maximum price and limits in investment and operating costs for the new technology as well a sensitivity analysis. The result shows an interesting tradeoff between investment and operating costs that define the path for developing a proposed new technology.

Calculations for modeling the WISS solution and the traditional system are detailed in Table 5.1 (and in Annex 5.2). The evaluation criterion was Cost Present Value (CPV) based on an Annual Discount Rate of 20% (Annex 4.1 b), and an evaluation horizon of 18 months as required by the seawater phase for Atlantic Salmon. The unit of study was one cage of culture, representing the production center and the industry. Each production center held 24 cages of fish culture.

Table 5.1 Calculation memory for modeling the traditional system and the WISS systems for net managing in the salmon industry in Chile.

Technological alternatives :	Mutually exclusive
Methodology :	Present Value
Evaluation criteria :	Minimum Cost PV
Annual Discount Rate of the Industry :	20%
Evaluation Horizon :	18 months
Specie :	Atlantic Salmon *(Salmo salar)*
Phase of Culture :	Fattening
Unit of study :	One cage of culture
Initial fish number in culture x cage :	41,667
Initial weight culture (gr.) :	100
Harvest weight (gr.) :	5,000
Number of days :	548
Number of cages per center :	24
Fattening period (months) :	18 months

Table 5.2 shows the programing for managing the nets culture considering the traditional system and the washing in situ proposal (Annex 5.3). The current activities in the net managing are installation, changes and extraction of each net in a center of production, which has 24 cages or fishnets. The unit costs for each of these activities are detailed in Annex 5.4 and 5.5. In the chart below can been seen that the differences between the traditional system and WISS solution are the changes of the fish nets in the month 7, 11 and 14, and the changes of the Seal proof-nets in the month 5, 10 and 14.

Table 5.2 Comparison programming for traditional and WISS alternatives

		N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A
# Month	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
TRADITIONAL NYLON NET	INSTALLATION				CHANGES			CHANGES			CHANGES				CHANGES				EXTRACTION
Fish-net	PCI-1,5				PCI-2			PCI-2			PCI-2				PCI-2				PCI-2
Sealproof net	LCI-10					LCI-10					LCI-10				LCI-10				LCI-10

# Month	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
NET + WASHING IN SITU	INSTALLATION				CHANGES														EXTRACTION
Fish-net	PCI-1,5				PCI-2														PCI-2
Washing in situ Fish-net					Washing in situ														
Sealproof net	LCI-10				Washing in situ														LCI-10

The model considered the cash flow expenses of incremental activities between the technological alternatives, i.e., changing fishnets of 2 inches and changing seal proof nets of 10 inches throughout the evaluation horizon, defined as ocean phase of salmon fattening. The expenses cash flow of each alternative and the unit costs are detailed in Annexes 5.4 and 5.5, which consider the programming of net managing activities (Annex 5.3).

Figures 5.1(a) and 5.1(b) show operating costs and accumulated expenses cash flow for each technology considering incremental changes in the fishnets for both systems. The blue line represents the operational cost for the traditional systems, which picked different expense amounts in different months (Annex 5.5). To compare both technologies, the Costs Present Value (CPV) of the traditional system was calculated with an annual discount rate of 20% (Annex 4.1 b).

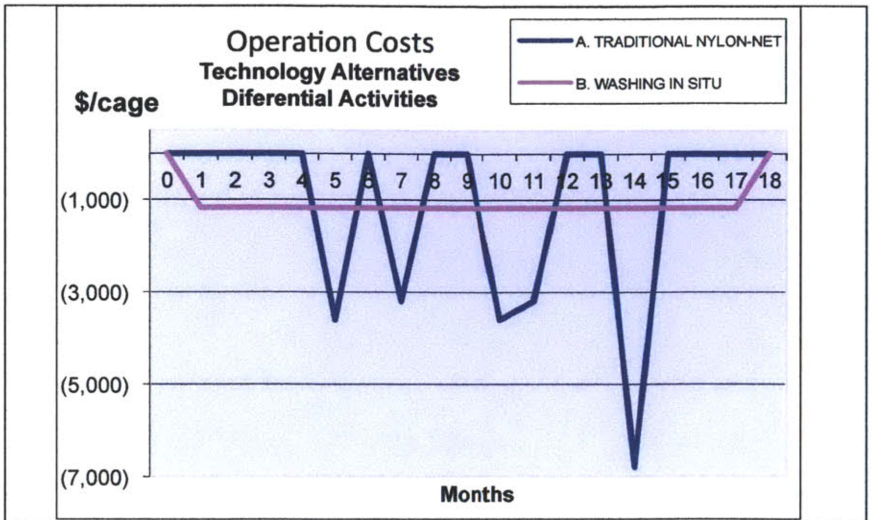


Fig. 5.1(a) Operating costs

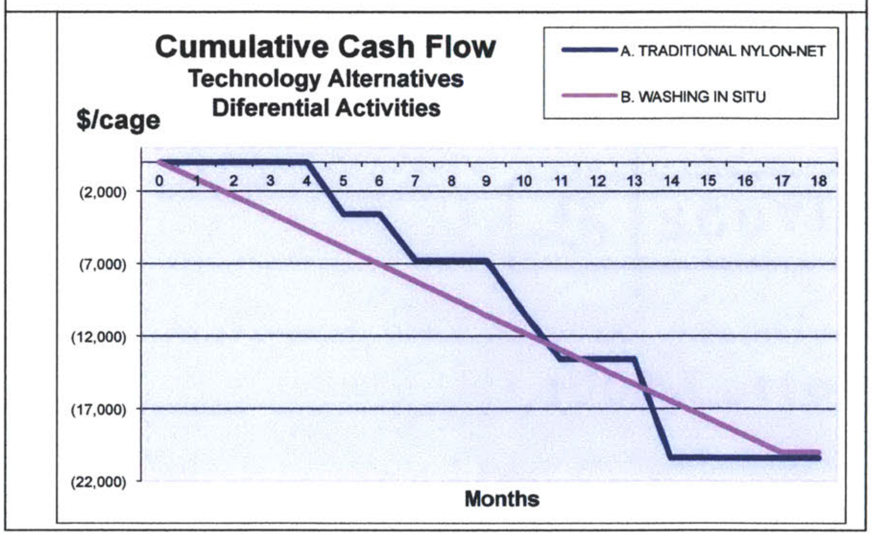


Fig. 5.1(b) Cumulative cash flow

In this way, the present value of the total cost of the traditional system was obtained. The CPV for managing the fishnets using the traditional system is $8.171 per cage (Table 5.3). This amount is the maximum feasible CPV of the WISS solution, because if the WISS approach has a higher CPV than the traditional system, it would not be implemented. So this value is the basis for calculating the indifference price of the new technology, defined as the price at which a salmon company is indifferent about the choice between the old and new technologies for managing nets in the production cycle.

Table 5.3. Cost Preset Value Traditional System

Cost PV (20%) $	
CPV Mngmt Fish-Net (PV$/cage/cycle):	$ 8,171
CPV Mngmt Seal proof-Net (PV$/cage/cycle):	$ 9,339
CPV Total both Nets (PV$/cage/cycle):	$ 17,511

The WISS solution creates a constant cash flow for expenses each month because the nets are maintained at a constant level of cleanliness and do not require change over the culture period. Thus, a CPV value of $8.171 per cage was used to calculate an equivalent cash flow with an equal amount each month throughout the evaluation horizon and a similar CPV of $8.171 per cage. The results of these calculations are detailed in Chapter 6.

In addition, the effect of the cost change of the traditional systems was considered in a sensitivity analysis that measured changes in the amount of the indifference price and therefore in the monthly amount of the cost of the technology proposal. It found a variation ranging from -25% to +25% of the traditional unit cost. The results are also detailed in Chapter 6.

5.2 Developing a Path for the New Technology

At this point, if the indifference price for the new technology and its possible variations due to the change of the cost of the traditional system for managing the nets in the fish fattening phase in the seawater, it is useful to calculate the limits of investment amount and operating costs for the new technology as a way to suggest the path toward the new technology.

The development path for the WISS approach, considering investment and operating costs is determined by using investment decision tools and takes the perspective of a supplier company able to deliver the WISS service to the Chilean salmon industry. The model considered an annual discount rate of 30% - the profitability required for a new technological startup company in the salmon farming industry. This discount rate was set based on experience with venture capitalist in the industry in Chile where they use discount rates between 20%-50% for evaluating investment in new companies in the sector. The evaluation criterion was maximization of its NPV. Table 5.4 details the values considered in the modeling, with a contribution margin of 20% (a common contribution margin for suppliers in the industry). At a minimum, the new service must decrease operating costs for managing nets in the seawater phase by 15%. Complete calculations can be found in Annex 5.6.

Table 5.4. Calculation memory for modeling the development of the WISS approach

Evaluation Level :	Prefeasibility
Technology :	WISS Fish-Net
Methodology :	Present Value
Evaluation Horizon :	18 months
Evaluation Criteria :	Max NPV
Annual Discount Rate Investor new Project :	30%
Annual Discount Rate Salmon Farming :	20%
Equivalent Monthly Discount Rate :	1.53%
Current Company Tax rate :	17%
Specie :	Atlantic Salmon *(Salmo salar)*
Unit of study :	One production center
Cages/Center :	24
Phase of Culture :	Fattening
Production cycle (months) :	18 months
GOAL Decrease Op. Costs Industry in :	-15%
Contribution Margin Average Op. (%) :	20%
Operation new machine (months/cycle) :	17
Useful life Fix Assets (months) :	36
Real useful life Fix Assets (months) :	60
Working Capital (months of Working Capital) (# months) :	2

Each indifference price between the technological alternatives was discounted 15% to determine the competitive price for the service using the WISS solution. Considering that the contribution margin must be 20%, it was possible to obtain operating costs for the WISS system. With the operating costs and profitability of 30% of CAPEX, a cash flow for this new technology was built which considered revenues defined using the market price for the service (-15% off the indifference price). The operating cost was calculated considering the contribution margin and an annual discount rate of 30% that meets the profitability requirement. In this way it was possible to calculate the amount of investment that fulfilled the required parameters.

Finally, having determined the amount of investment for the WISS technology and its operating costs, it was possible obtain a relative trade-off between both variables. That is, it is possible to know how much investment is permitted given the operating cost. The results are detailed in Chapter 6.

Chapter 6. Results and Discussion

The structure of the market for salmon farming is defined as open, highly competitive, with a product that is becoming commoditized, medium entry barriers, and close substitutes. As I have said several times, these factors mean the Chilean salmon industry must increase productivity and reduce costs in order to obtain and retain a sustainable position.

Yet, as noted, the industry is in good shape globally for facing new challenges. Despite the close call stemming from effects of the sanitary crisis in 2007, the industry continues to enjoy to several competitive advantages, including favorable environmental conditions in the south of the country, clean water and thousands of miles of islands, fjords, and protected bays that favor the culture of salmon. In addition, the know-how that has been developed, the competitive production factors, and the cluster developed give strong support to the industry.

Notwithstanding Chile's position in the salmon industry, technological change and innovations are necessary for generating growth and sustainability. Due to the market structure and product characteristic, technological changes must be directed toward reaching a leadership position in terms of costs that permit reducing the market price, which in turn will increase market share—in this way obtaining a sustainable position with enhanced profits.

Three models were built to fine-tune the innovation efforts and possible technological changes in the industry:

- The first model simulated salmon production from the standpoint of a production company. It identified variables that had major impacts on the performance indicators (NPV) of the average company, enabling it to know where to focus innovation efforts in the value chain for producing salmon (see Annexes 4.1, 4.2, 4.3 and 4.4).
- The second model focused on production cost as a direct outcome from the first model as well as the structure of the market, especially in terms of costs required to manage the fishnets in the seawater phase of the production cycle. The model compared activities between the traditional system (which requires several changes of nets and delivery of the nets to special facilities on land for cleaning), and the WISS

approach (in which it is not necessary to change the nets and is able to maintain clean nets all the time on site using a special device). The model calculated the indifference prices for both technologies that would face a production company manager (see Annexes 5.2, 5.3, 5.4, 5.5, and 5.6).

- The third model simulated implementation of the WISS approach from an entrepreneurship standpoint, i.e., a new supplier company that could offer the service to the industry. The model identified the investment and operating costs necessary to invest in this innovation considering a return over the investment of 30% necessary to assume the risk from the point of view of Venture Capitalist in fish farming projects in Chile, and at the same time reducing the production costs of the industry (see Annex 5.7).

6.1 Innovation Path Derived From the Models

The defined innovation path makes sense in the structure of the industry and the competitive strategy recommended for the Chilean companies in the context of the global market. With low production cost, it is feasible to become a cost leader, which is key to obtaining a sustainable and competitive position in the industry. Moreover, a reduced cost for nets management, possibly including outsourcing services, means moving to lower marginal costs—a key tool for maintaining a stable position when there are shocks in the market as prices change due to new competitors.

An alternative path to reducing production costs might be to increase the biomass per production unit by, for instance, planting more smolts at the beginning of the production cycle or obtaining extra biomass in the harvesting period to create larger growth rates. Note that an increase in biomass means more kilograms per volume, which could result in a higher sanitation risk. It is advisable to explore the possibility of obtaining higher growing rates where, rather than harvesting higher biomass, it could shorten the production cycle, thereby avoiding sanitation risks and reducing production costs.

Higher growth rates could be obtained through market-friendly genetic management or by bringing better production conditions to the fish. The management of nets solution focuses on this second point, improving the quality of water and oxygen, and creating fewer sources of pathogens while improving the culture conditions.

It is noteworthy that production costs directly affect the amount of working capital needed, so by reducing costs, the industry can also reduce the amount of initial investment. The reduction of production costs is the right path for the industry to pursue, and innovations and technological changes are key.

6.2 Case Study Results: Defining an Innovation Path

The case study proposed using the WISS system as the most feasible solution. This approach, as noted, involves the regular cleaning of the nets in the salmon culture site using a special device that avoids fouling and requires fewer net changes as the traditional system does. So, it is possible to obtain lower operating costs (see Annex 5.2).

The WISS approach focused on an innovation path that reduces the cost of production for a salmon company implementing a system of net management during the seawater phase during the short to middle term. This solution could be developed and implemented in the short term without a large investment in R&D and implementation costs. The salmon industry in Chile already enjoys some advances in the concept: There are no important patents or special materials involved which require payment of royalties; the salmon companies already have a strong supply chain, existing technological centers, and human capital able to fully develop and implement this solution.

Table 6.1 details the indifference price for the WISS solution if applied to fishnet, seal proof-net, and both. The prices are the maximum tariff a salmon company is willing to pay for net management. For instance, the maximum tariff for fishnet should be $550 per cage per month, equivalent to a contract of K$224 per center per production cycle of 18 months (see Annex 6.1). The discount rate used to calculate the prices was 20% considering a calculation of the cost present value (CPV) of the traditional system as reference point for defining the indifference prices. This discount rate is representative of the Chilean salmon industry. Note, the WISS solution considers a monthly payment with a constant amount of money for the services, in this case $13,190 per center per month ($550 per cage per month), to maintain clean nets and avoid changes. The prices of indifference are based on the actual costs of the traditional system for managing the nets. Thus, if there is a change in the cost of the traditional technology, prices will also be changed. Annex 6.2 details the indifference prices for the fishnet and the seal proof-net considering changes in the costs of the traditional system of -25% to +25%. Sensitivity analysis was applied, which measured the changes given the range of variation. The indifferences prices fluctuated between $412 and $687 per cage per month, according to the range of variation defined for the cost of the traditional system.

Table 6.1 Indifference tariff using the WISS solution

	Washing Fish Net	Washing Seal proof Net	Washing Fish + Seal proof Net
Tariff ($/cage/month) :	$ 550	$ 628	$ 1,178
Tariff ($/cage/cycle) :	$9,343	$10,678	$20,021
Tariff ($/m2/month) :	$0.25	$0.10	$0.14
Tariff ($/center/month) :	$13,190	$15,075	$28,265
Tariff (K$/center/cycle) :	K$224	K$256	K$481

6.3 Competitive Tariff and Goals in the Developing New Technology

The adoption of the WISS system depends on the market price set for services to maintain clean nets, considering high cost sensitivity by the companies and an expectation that the WISS system will have at least the same results as the traditional system for net management. As starting point, the model was predicated on the service being 15% less compared to the traditional solution, meaning lower production costs for salmon companies, and a competitive tariff.

Table 6.2 shows the competitive price, operating costs, and maximum investment per production center to implement service using the WISS technology (calculations are detailed in Chapter 5 and Annex 5.7.) The operating cost of the proposal was determined based on a contribution margin of 20%, which is common among the suppliers in the salmon industry. The amount of investment was calculated considering a return over the investment or annual discount rate of 30%, based on requirement from venture capitalist in the sector in Chile and characteristic of companies in start-up phase of aquaculture.

Table 6.2. Price, operating costs and investment for the WISS solution

Revenues & Costs	Reduce price ($/cage/month) :	$467.15
	Operation cost ($/cage/month) :	$ 373.72
CAPEX	CAPEX per production center ($) :	$ 43,986
	Working capital ($) :	$ 17,938

The competitive price or tariff set for the WISS solution was calculated as $467.15 per cage per month, equivalent to K$191 per center per production cycle of 18 months. The operating cost of this new technology should be around $373 per cage per month (K$152 per center per cycle) and would require an investment maximum of K$44 per production center in order to obtain a probability of 30%. If this competitive tariff is compared with the indifference price calculated above, there is value creation measured as present value at 20% of K$29.4 per center per cycle, or in terms of tariff a reduction of $82 per cage per month (Table 6.3). The cash flow used for calculating the competitive tariff, operating costs, and limits of investment are detailed in Annex 6.3.

Table 6.3. Price of service and value creation using the WISS system compared with the traditional system

	Indifference Price	**Reduce Price**	**Dif. Value**
Tariff ($/cage/month) :	549.59	467.15	82.44
PV COSTS (20%) $/cage/cycle :	8,171	6,946	1,226
PV COSTS (20%) $/center/cycle :	196,116	166,698	29,417
Tariff ($/cage/cycle) :	$9,343	$7,942	$1,401
Tariff ($/center/month) :	$13,190	$11,212	$1,979
Tariff (K$/center/cycle) :	K$224	K$191	K$34

Annex 6.4 provides a detailed sensitivity analysis of the WISS solution. It modeled changes in the operating cost of the traditional system and how it affected the requirements for operating cost and investment in the new technology proposal. For instance, if the cost of the traditional system increases 5%, the competitive tariff could be $491 per cage per month (K$200 per center per productive cycle). Considering a 20% contribution margin, the goal in the developing process for operating cost would be $392 per cage per month, with a maximum investment per center of K$46.1 to obtain a profitability of 30%.

With this approach and results, it is possible to define a path for achieving innovation goals and development process for the WISS system. However, it is critical to calculate the limits of investment and the operating cost of the new technology, and each decision must be guided toward the results sought. For example, the model shows that the WISS system should operate at a maximum in $374 per cage per month (K$152 per center per production cycle), with a maximum investment of K$44 per equipment per center, and a market price that is 15% less compared to the traditional system.

6.4 Tradeoff Between Investment and Cost: Its Effect on Developing the Path for a New Technology

It is important to understand that there is a tradeoff between cost and investment in the process of developing the new technology proposal and this tradeoff is limited for the financial performance require in order to serve commercially the target market. For instance, you can use better materials and components or use robotics marine technology for creating an autonomous solution, this will increase the amount of investment in the new technological device, but, at the same time, you will obtain less operating costs due to less maintenance require for the quality of the materials and less human labor require for the operation of the new technology. Also, the tradeoff could be defined as the sensitivity of the new technology in its commercial phase with respect to cost and investment, which is essential for raising capital and implementation in the market. For instance, if economic performance in the commercial phase of the new technology is more sensitive to cost, then development efforts should be directed toward decreasing operating costs of the new technology, even if it means increasing the investment, since the commercial performance of the new technology is less sensitive to investment. So, creating a tradeoff between costs and investment is essential for defining the developing path of the new solution proposal.

The tradeoffs between cost and investment are detailed in Table 6.4, with additional details in Annex 6.5. The tradeoff was calculated using a starting point that produces the profitability of 30% in the commercial phase, a 20% contribution margin, and a commercial price of $467 per cage per month—15% less than the indifference price of the traditional system. The model changed to operating costs in a range of -25% to +25%, an investment needed to bring 30% profitability, and a fixed commercial price of $467 per cage per month.

Analysis showed that an inverse relation exists between costs and investment. For instance, if cost increases, investment must decrease in order to maintain the economic performance of 30% of profitability or required return over the investment from the point of view of an investor in the sector in Chile. If operating costs increase 5%, the contribution margin decreases from 20% to 16%, and the investment required will be K$32 per center rather than K$44 original. Note there is a limit in the increment of operating cost; anything over 20% puts pressure on price to market rather on investment. Notice the amount of negative investment at this point in the table and the ensuing results.

The tradeoff between cost and investment is defined by :

$$\partial I/\partial C = -5.44$$

Table 6.5. Tradeoff between investment & cost of new technology

dI/dC :	-5.4404
Operating cost ($/cage/month) :	374
Operating costs (K$/center/cycle) :	K$152
Investment in new technology (K$/center) :	K$44.0

This relation was obtained by working with the data in Table 6.4. It is negative and depends on the constraints, in this case the profitability required and the commercial price in the market for servicing the new technology (see Annex 6.6). It explains the change in the amount of investment when the operating cost of the new technology is changed. For instance, if operating costs decrease by 1%, the amount of investment in equipment for the new technology could increase by 5.4%. Also, this illustration can be used to calculate the amount of operating cost required if there is a change in the amount of investment.

Figure 6.1 shows the relationship between the amount of investment, considering 30% profitability, when the operating cost of the traditional system (blue line) is changed, and the relationship of operating costs of the new technology in the development phase (red line).

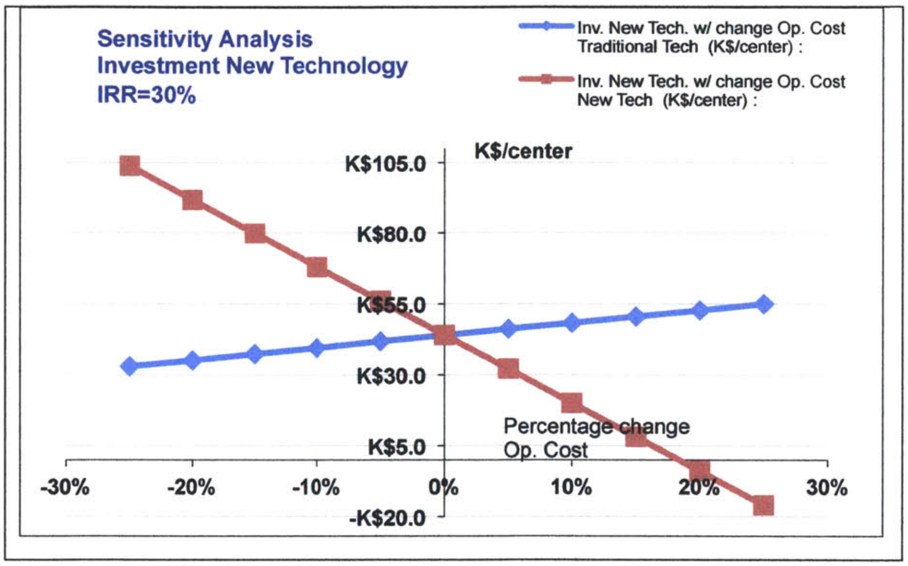


Fig. 6.1 Analysis of investment requirement when factors are changed

The tradeoff between cost and investment is a powerful tool for guiding the development path of the new solution considering decisions that involve operating costs and investment, i.e., decisions about type of energy, maintenance, or materials to use in the development of the WISS system.

Table 6.4. Investment in new technology when operating costs of the new technology are changed

Rate of cost change:	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%	25%
Competitive tariff ($/cage/month):	$467	$467	$467	$467	$467	$467	$467	$467	$467	$467	$467
Tariff (K$/center/cycle):	K$191	K$191	K$191	K$191	K$191	K$191	K$191	K$191	K$191	K$191	K$191
Operating cost ($/cage/month):	280	299	318	336	355	374	392	411	430	448	467
Operating costs (K$/center/cycle):	K$114	K$122	K$130	K$137	K$145	K$152	K$160	K$168	K$175	K$183	K$191
Contribution margin (%):	40%	36%	32%	28%	24%	20%	16%	12%	8%	4%	0%
IRR %:	30%										
CAPEX in new technology (K$/center):	K$104	K$92	K$80	K$68	K$56	K$44	K$32	K$20	K$8	-K$4	-K$16
Change %:	136%	109%	82%	54%	27%	0%	-27%	-54%	-81%	-109%	-136%

Chapter 7. Summary: Practical Application, Next Steps, and Recommendations

The WISS solution was chosen because it aligns with the innovation path recommended for the industry, and it was possible to calculate its competitive tariff, operating costs, and investment limits as well define its development path. The WISS solution aligns with the industry's need to increase productivity, competitiveness, and sustainability.

The WISS technology is superior compared to the traditional system of net management because it will permit cost reductions in fish net management, and simplifies operations to avoid the use of key resources such as scuba divers and complicated logistics. The solution also constantly maintains clean fishnets, improves production and sanitation conditions at less cost and less risk. Therefore, the WISS solution is a realistic choice for the industry when developed along the recommended pathway, and it could be commercially implemented at a competitive tariff, reduced operating costs, and less investment.

Managing the nets has traditionally been performed by suppliers. The salmon producers companies are focused on their core business—the production of salmon—and most of the support activities have been outsourced. Considering that the WISS solution needs capabilities in technology and in submarine operations, I suggest that the WISS solution be implemented by a service company which then delivers it to the industry at a competitive price following the development path recommended. The selected supplier must be a low-cost, high-efficiency service provider capable of delivering fishnet cleaning services at a significant cost saving and with operating simplicity. The supplier's business model must consist of maintaining clean fishnets at a monthly service fee; a thorough WISS that avoids the costs and hassles associated with traditional procedures. Also, this solution will be aligning with the traditional way of the industry for managing net-changes through outsourcing, so, the adoption of this new technology should be welcome and without big changes in the productive companies.

The steps for forming a new company follow. First, a venture team must be built, headed by an expert in fish farming operations, an expert in technological development, a team member with management experience, and a team member with wide-ranging network for raising capital with venture capital investors to finance the company.

The second step is to present the project to investors, raise capital, and develop the first prototype of the WISS solution.

The third step is a trial of the prototype in real conditions at a production center, to see how the solution performs and identify areas for improvement.

Finally, the four step is to begin commercial operations and a second round to raise investment capital, thereby ensuring the growth of the new company and its capacity to create and capture value.

Chapter 8. Conclusion

Chile has a solid position in the world salmon market as a key producer. However, for sustainable growth and competitiveness, it is necessary to identify new innovations and make technological changes in the industry. The market is highly competitive, with low to medium barriers of entry; demand is elastic; and the product is becoming commoditized. Consequently as noted in the chapter 1, the recommended competitive strategy is that Chile becomes a leader by reducing costs and transferring those savings to the market price, which will increase market share and, ultimately, profits.

A viable innovation path was identified through modeling the industry and undertaking a case study using investment decision tools, cash flow and present value (refer back to Chapters 3 and 4). The best innovation path for the industry is one that focuses on production costs. Note, however, that sales price is a critical variable.

In the short term, the recommended innovation path should focus on reducing the cost of production for managing nets in the seawater phase. For the long term, the innovation path should focus in food, a feeding system, production of smolts, and improvement of growth rates in the fattening phase.

The case study proposed using the washing in situ system (WISS), which aligns with innovation path recommended for the short term. It was possible to calculate its competitive tariff, operating costs, and needed investment. WISS is an alternative to the traditional net management system, but all signs point to it being a strong possibility in the industry. If implemented in the short term it does not require a huge amount of R&D investment, there are no special patents or industrial/intellectual property rights, and the industry has an efficient supply chain capable of offering the requisite services.

Adoption of the WISS approach depends on the market price set for services to maintain clean nets. Based on that, implementation of the WISS solution was modeled with a price of 15% less than the cost of the traditional system of changing nets. This created a savings to the production company of K$34 per center per cycle (18 months); on average each company has 10 to 15 production centers.

The results of the modeling set the competitive price of the WISS solution at $467 per cage per month, equivalent to K$191 per center per production cycle of 18 months. To achieve that requires an investment maximum of K$44 per production center to obtain a profitability of 30%. The model had an annual discount rate of 20%. The operating cost of this new technology should be close to $373 per cage per month (K$152 per center per cycle), based on a contribution margin of 20%, representative of the suppliers in the industry.

The modeling revealed a tradeoff between cost and investment quantified as -5.44. This tradeoff is essential for defining the development path of the new proposal, and calculating a change in operating cost versus change in investment needed to maintain commercial viability. In this case, if operating costs decrease by 1%, the amount of investment in new technology equipment could increase until 5.4% for maintaining commercial viability. Looked at another way, this relationship can be used to calculate the amount of operating cost required if there is a change in the amount of fixed investment for the developing process. In addition, this relationship is key to defining the R&D effort required to develop the WISS solution and the desired investment and operating cost goals for this new technology.

So, it is important calculate limits on the amount of investment and operating costs of the new technology as a way to focus development effort. Also, the tradeoff relationship between cost and investment in the commercial phase of implementing the new technology is a powerful tool for making better decisions. For instance, if the new technology is more sensitive to cost (as is the case with the WISS solution), development efforts should be directed toward decreasing operating costs, even if this means increasing the required investment. Thus, each decision in this process must be guided by the relationships and the amounts calculated.

The methodology and the model developed are tools for defining the best innovation path and the process of developing a new technology (or solution) that will maintain the Chilean salmon farming industry as an innovative market leader. Also, valuable data was obtained for guiding the innovation effort. Benchmarks also developed to mark the WISS solution.

Finally, I recommend that a new company be created, a low-cost/high-efficiency service provider for the industry; one that delivers fish net cleaning services for salmon farming, this allow for significant cost savings, bringing in the industry more operating simplicity and will be align with the way to operate in the industry through outsourcing of the net-managing activities. This will require team building, building a prototype for the WISS solution, and raising investment and operating capital.

Annexes

Annex 2.1

Table I. Global production salmon & trout, wild and farming 1981-2008 (thousand tons rounded)

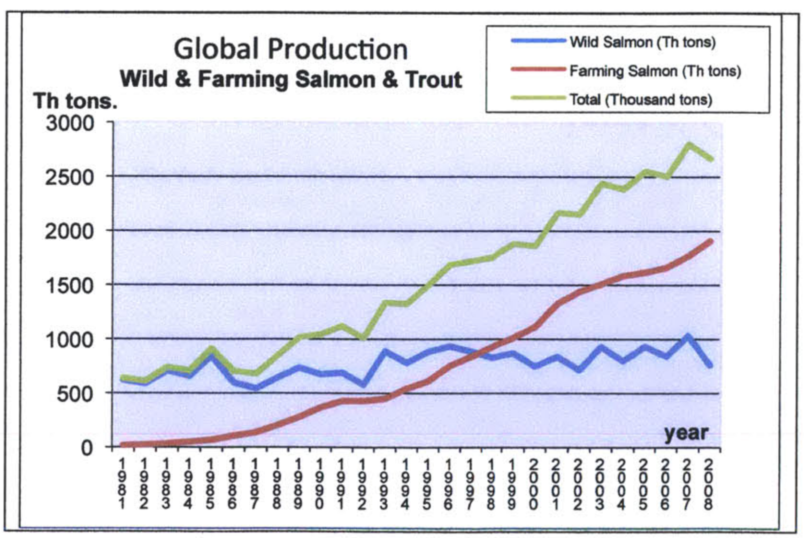
	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Wild Salmon	620	589	708	658	844	597	542	645	737	676	691
Farming Salmon	17	21	32	49	67	104	136	204	278	366	427
Total	637	610	740	707	911	701	678	849	1015	1042	1118
% Farming Salmon	3%	3%	4%	7%	7%	15%	20%	24%	27%	35%	38%
Times Farming over wild	0.0 x	0.0 x	0.0 x	0.1 x	0.1 x	0.2 x	0.3 x	0.3 x	0.4 x	0.5 x	0.6 x

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Wild Salmon	579	890	782	884	934	884	827	869	749	838	715
Farming Salmon	429	447	543	612	751	835	926	1010	1112	1327	1438
Total	1008	1337	1325	1496	1685	1719	1753	1879	1861	2165	2153
% Farming Salmon	43%	33%	41%	41%	45%	49%	53%	54%	60%	61%	67%
Times Farming over wild	0.7 x	0.5 x	0.7 x	0.7 x	0.8 x	0.9 x	1.1 x	1.2 x	1.5 x	1.6 x	2.0 x

	2003	2004	2005	2006	2007	2008e	2009e	2010e	2011e	2012e	2013e
Wild Salmon	930	799	932	841	1033	761	755	748	742	736	730
Farming Salmon	1508	1586	1617	1661	1768	1907	1958	2011	2064	2120	2176
Total	2438	2385	2549	2502	2801	2668	2713	2759	2807	2856	2906
% Farming Salmon	62%	66%	63%	66%	63%	71%	72%	73%	74%	74%	75%
Times Farming over wild	1.6 x	2.0 x	1.7 x	2.0 x	1.7 x	2.5 x	2.6 x	2.7 x	2.8 x	2.9 x	3.0 x

Average Growth rate

	1998	2008	Average Growth rate	1981	2008	Average Growth rate
Wild Salmon	827	761	**-0.83%**	620	761	**0.76%**
Farming Salmon	926	1906	**7.49%**	17	1906	**19.10%**
	1753	2667		637	2667	



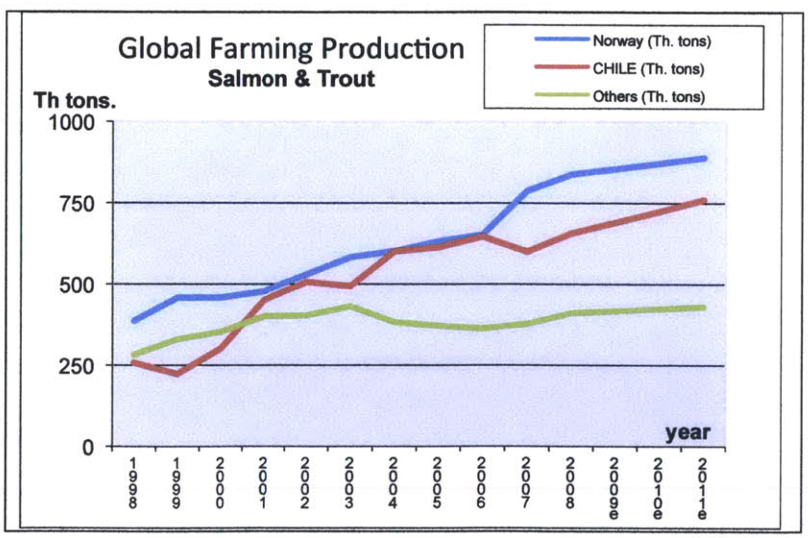
Annex 2.2

TABLE I. Global farming production of salmon & trout by country 1998-2008 (thousand tons rounded)

Country	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Australia	11	10	14	13	13	14	15	18	17	18	26
Canada	47	63	79	84	118	109	107	124	125	119	126
Chile	258	223	302	450	506	494	601	614	647	601	657
Denmark	6	6	6	6	6	6	6	6	6	7	9
Faroe Island	25	37	33	52	52	58	41	18	16	24	40
Finland	18	18	20	20	18	18	16	16	16	16	15
Iceland	6	4	3	6	4	4	6	7	4	2	1
Ireland	22	21	19	22	22	19	16	14	15	16	15
Japan	10	12	10	12	9	9	10	12	10	9	9
New Zealand	8	8	6	8	8	7	9	9	9	9	11
Norway	387	458	459	478	530	583	602	632	652	789	839
Sweden	7	7	7	7	7	7	7	7	7	7	5
UK	100	120	134	147	133	162	137	130	128	139	137
USA	22	24	22	24	13	18	13	10	10	12	17
TOTAL	927	1011	1114	1329	1439	1508	1586	1617	1662	1768	1907

TABLE II. Participation by country, growth rates and projections

Country	2008	% part	% Growth 1998-2008	2012	2020	Projected Growth %
Canada	126	7%	10.4%	142	180	3.0%
Chile	657	34%	9.8%	799	1180	5.0%
Norway	839	44%	8.0%	908	1064	2.0%
UK	137	7%	3.2%	142	153	0.9%
Others	148	8%	0.92%	148	148	0.0%
Total	1907	100%	7.48%	2139	2724	0.00%



Annex 2.3

TABLE I. Chile's exports of salmon by region & country (2006-2010)

DESTINATION REGION - COUNTRY	Quantity (Net tons)					PRE SANITARY CRISIS		POST SANITARY CRISIS	
	2006	2007	2008	2009	2010	% part 2008	% growth 2006-08	% part 2010	% growth 2008-10
JAPAN	148,729	164,814	177,389	168,279	154,672	32%	9.21%	44%	-6.62%
USA	108,763	119,218	113,576	75,159	57,145	21%	2.19%	16%	-29.07%
LATIN AMERICA	29,384	41,579	60,198	66,738	55,605	11%	43.13%	16%	-3.89%
EUROPEAN UNION	46,406	51,077	50,376	29,166	11,239	9%	4.19%	3%	-52.77%
OTHER MARKETS	53,859	121,672	144,411	118,726	73,977	26%	63.75%	21%	-28.43%
TOTAL:	**387,141**	**498,360**	**545,950**	**458,068**	**352,637**	100%	18.75%	100%	-19.63%

Source: Statistics Aqua.cl, 2012

TABLE II. Value of the Chilean salmon export by region - country (2006-2010).

DESTINATION REGION - COUNTRY	Export Value (millions of US$ FOB)					PRE-SANITARY CRISIS		POST-SANITARY CRISIS	
	2006	2007	2008	2009	2010	% part 2008	% growth 2006-08	% part 2010	% growth 2008-10
JAPAN	$ 704	$ 663	$ 720	$ 836	$ 921	29	1.13%	43%	13.10%
USA	$ 792	$ 864	$ 800	$ 559	$ 466	32%	0.49%	22%	-23.66%
LATIN AMERICA	$ 156	$ 206	$ 276	$ 298	$ 349	11%	33.11%	16%	12.39%
EUROPEAN UNION	$ 308	$ 293	$ 294	$ 164	$ 67	12%	-2.44%	3%	-52.21%
OTHER MARKETS	$ 246	$ 299	$ 401	$ 316	$ 329	16%	27.60%	15%	-9.42%
TOTAL:	**$2,207**	**$2,326**	**$2,490**	**$2,174**	**$ 2,132**	100	6.24%	100%	-7.48%

Source: Statistics Aqua.cl, 2012

TABLE III. Price US$ FOB/ kilo of Chilean salmon exported by region/country (2006-2010)

DESTINATION REGION - COUNTRY	Price FOB (US$ x kilo)					Pre-crisis	Post-crisis	Total Period
	2006	2007	2008	2009	2010	% growth 2006-08	% growth 2008-10	% growth 2006-10
JAPAN	$ 4.73	$ 4.02	$ 4.06	$ 4.97	$ 5.95	-7.40%	21.12%	5.91%
USA	$ 7.28	$ 7.24	$ 7.04	$ 7.44	$ 8.16	-1.66%	7.63%	2.88%
LATIN AMERICA	$ 5.30	$ 4.96	$ 4.59	$ 4.47	$ 6.27	-7.00%	16.94%	4.28%
EUROPEAN UNION	$ 6.65	$ 5.74	$ 5.83	$ 5.63	$ 5.97	-6.37%	1.19%	-2.66%
OTHER MARKETS	$ 4.57	$ 2.46	$ 2.77	$ 2.66	$ 4.44	-22.07%	26.55%	-0.69%
TOTAL:	**$5.70**	**$4.67**	**$4.56**	**$4.75**	**$6.05**	-10.54%	15.12%	1.48%

Source: Statistics Aqua.cl, 2012

Annex 2.4

TABLE I. Exports of Chilean salmon, by species (2006-2010)

SPECIES	Quantity (Net tons)					PRE SANITARY CRISIS		POST SANITARY CRISIS	
	2006	2007	2008	2009	2010	% part 2008	% growth 2006-08	% part 2010	% growth 2008-10
ATLANTIC SALMON	213,298	206,266	232,316	181,966	93,271	43%	4.4%	26%	-36.6%
COHO SALMON	79,350	78,442	88,536	89,797	84,075	16%	5.6%	24%	-2.6%
KING SALMON + without/esp	1,271	102,600	100,271	87,252	49,080	18%	788.2%	14%	-30.0%
TROUT + BROWN TROUT	93,222	111,053	124,827	99,051	126,212	23%	15.7%	36%	0.6%
TOTAL:	**387,141**	**498,361**	**545,950**	**458,066**	**352,637**	100%	18.8%	100%	-19.6%

Source: Statistics Aqua.cl, 2012

TABLE II. Value of Chilean salmon exports, by specie (2006-2010)

SPECIE	Export Value (millions of US$ FOB)					PRE SANITARY CRISIS		POST SANITARY CRISIS	
	2006	2007	2008	2009	2010	% part 2008	% growth 2006-08	% part 2010	% growth 2008-10
ATLANTIC SALMON	$ 1,418	$ 1,434	$ 1,497	$ 1,085	$ 725	60%	2.8%	34%	-30.4%
COHO SALMON	$ 299	$ 281	$ 299	$ 422	$ 437	12%	0.0%	21%	20.9%
KING SALMON + without/esp	$ 8	$ 88	$ 100	$ 73	$ 67	4%	254.8%	3%	-18.3%
TROUT + BROWN TROUT	$ 482	$ 523	$ 594	$ 594	$ 902	24%	11.0%	42%	23.2%
TOTAL:	**$ 2,207**	**$ 2,326**	**$ 2,490**	**$ 2,174**	**$ 2,132**	100%	6.2%	100%	-7.5%

Source: Statistics Aqua.cl, 2012

TABLE III. Price $US FOB/kilo Chilean salmon exports, by specie (2006-2010)

SPECIE	PRECIO FOB (US$ x kilo)					Pre-crisis	Post-crisis	Total Period
	2006	2007	2008	2009	2010	% growth 2006-08	% growth 2008-10	% growth 2006-10
ATLANTIC SALMON	$ 6.65	$ 6.95	$ 6.44	$ 5.96	$ 7.78	-1.5%	9.8%	4.0%
COHO SALMON	$ 3.77	$ 3.58	$ 3.38	$ 4.69	$ 5.20	-5.3%	24.1%	8.4%
KING SALMON + without/esp	$ 6.28	$ 0.86	$ 1.00	$ 0.84	$ 1.37	-60.1%	16.8%	-31.7%
TROUT + BROWN TROUT	$ 5.17	$ 4.71	$ 4.76	$ 6.00	$ 7.15	-4.0%	22.6%	8.5%
TOTAL:	**$ 5.70**	**$ 4.67**	**$ 4.56**	**$ 4.75**	**$ 6.05**	-10.5%	15.1%	1.5%

Annex 2.5

TABLE I. Chilean salmon export, by product type (2006-2010)

PRODUCT	Quantity (Net tons)					PRE SANITARY CRISIS		POST SANITARY CRISIS	
	2006	2007	2008	2009	2010	% part 2008	% growth 2006-08	% part 2010	% growth 2008-10
FROZEN	286,220	287,797	328,181	284,011	223,265	60%	7.1%	63%	-17.5%
FRESH	86,770	97,497	106,283	71,198	61,859	19%	10.7%	18%	-23.7%
Preserve, Salted, Smoked & Live	14,154	11,752	11,130	13,994	12,037	2%	-11.3%	3%	4.0%
FISH MEAL - OIL		101,314	100,355	88,863	55,477	18%	#DIV/0!	16%	-25.6%
TOTAL:	**387,144**	**498,360**	**545,949**	**458,066**	**352,637**	100%	18.8%	100%	-19.6%

Source: Statistics Aqua.cl, 2012

TABLE II. Value of Chilean salmon export, by product (2006-2010)

PRODUCT	Export Value (millions of US$ FOB)					PRE SANITARY CRISIS		POST SANITARY CRISIS	
	2006	2007	2008	2009	2010	% part 2008	% growth 2006-08	% part 2010	% growth 2008-10
FROZEN	$ 1,503	$ 1,484	$ 1,612	$ 1,501	$ 1,435	65%	3.6%	67%	-5.6%
FRESH	$ 589	$ 655	$ 674	$ 478	$ 508	27%	7.0%	24%	-13.2%
Preserve, Salted, Smoked & Live	$ 114	$ 106	$ 105	$ 122	$ 118	4%	-4.3%	6%	6.1%
FISH MEAL – OIL		$ 82	$ 100	$ 73	$ 71	4%	#DIV/0!	3%	-15.7%
TOTAL:	**$ 2,207**	**$ 2,326**	**$ 2,490**	**$ 2,174**	**$ 2,132**	100%	6.2%	100%	-7.5%

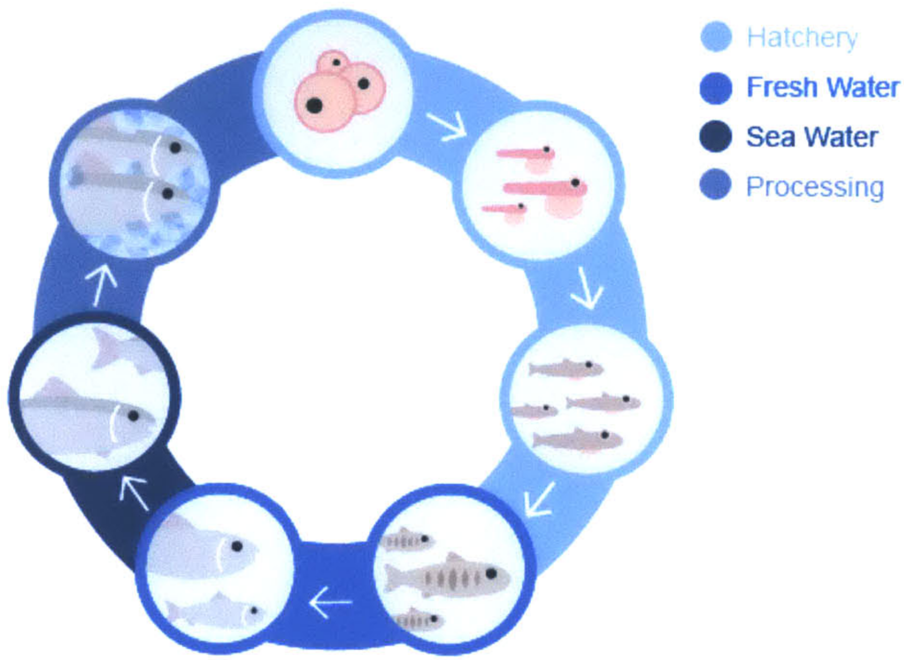
Source: Statistics Aqua.cl, 2012

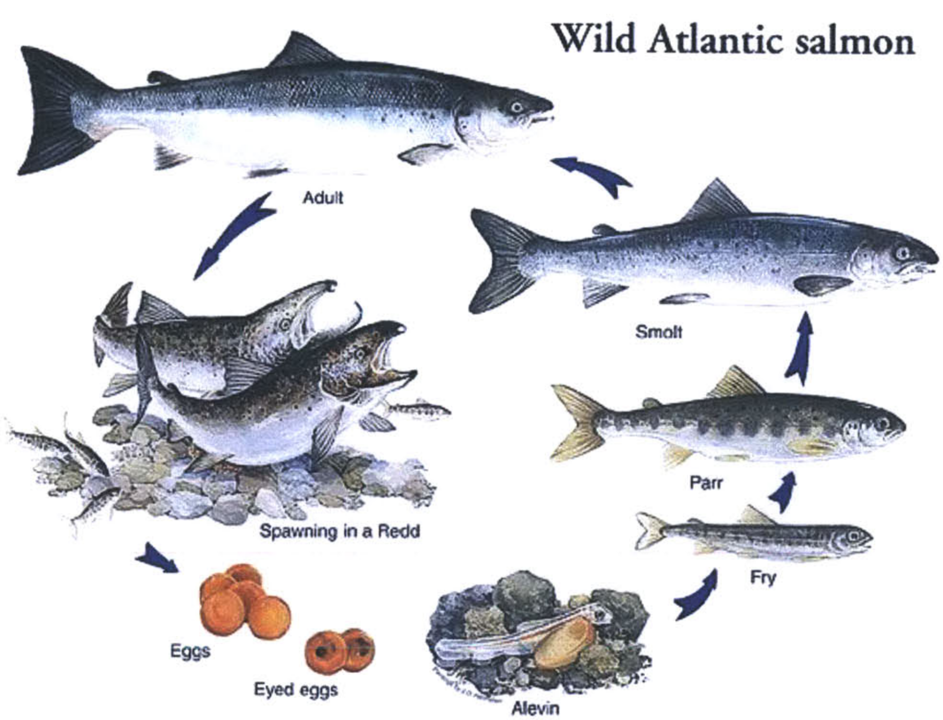
TABLE III. Price $US FOB/kilo of Chilean salmon export, by product (2006-2010)

PRODUCT	PRICE FOB (US$ x kilo)					Pre-crisis	Post-crisis	Total Period
	2006	2007	2008	2009	2010	% growth 2006-08	% growth 2008-10	% growth 2006-10
FROZEN	$ 5.25	$ 5.16	$ 4.91	$ 5.28	$ 6.43	-3.3%	14.4%	5.2%
FRESH	$ 6.79	$ 6.71	$ 6.35	$ 6.72	$ 8.22	-3.3%	13.8%	4.9%
Preserve, Salted, Smoked & Live	$ 8.07	$ 9.02	$ 9.40	$ 8.75	$ 9.78	7.9%	2.0%	4.9%
FISH MEAL - OIL	#DIV/0!	$ 0.80	$ 0.99	$ 0.82	$ 1.28	#DIV/0!	13.4%	#DIV/0!
TOTAL:	**#DIV/0!**	**$ 4.67**	**$ 4.56**	**$ 4.75**	**$ 6.05**	#DIV/0!	15.1%	#DIV/0!

Annex 2.6

Salmon Farming in Chile: production cycle





Annex 2.7
Freshwater production cycle, equipment, and facilities

Photograph 1. Salmon eggs, first stage in the production cycle.

Photograph 2. Salmon alevins, second stage in the production cycle.

Photograph 3. Salmon Juvenile in freshwater tanks in land facilities.

Photograph 4. Salmon smolts in freshwater tanks ready for transfer to seawater.

Photograph 5. Typical hatchery facilities on land for salmon smolt production.

Photograph 6. Typical hatchery facilities on land for salmon smolt production.

Annex 2.8
Transporting smolts to seawater facilities

Photograph 1. Typical hatchery facilities with indoors tanks for smolts production.

Photograph 2. Typical Hatchery facilities with outdoor tanks for smolts production.

Photograph 3. Transport smolts to seawater by land transport systems.

Photograph 4. Wellboat with tanks for transporting smolts to seawater system.

Photograph 5. Wellboat transferring smolts to the culture site in seawater system.

Photograph 6. Typical culture cage in a seawater production center.

Annex 2.9

Seawater system and transport to facilities on land for processing and export to market

Photograph 1. Typical production center, fattening phase in seawater.

Photograph 2. Typical production center, fattening phase in seawater.

Photograph 3. Activities in the production center, seawater phase.

Photograph 4. Activities in the production center, seawater phase.

Photograph 5. Typical wellboat, harvesting ship transporting salmon to processing plant.

Photograph 6. Processing plant.

Annex 4.1

a) Calculation memory and parameters considered in modeling salmon farming in Chile

	Calculation	
Overall	Evaluation Level :	Predictability
	Species :	Atlantic Salmon *(Salmo salar)*
	Unit of study :	One production center
	Period considered :	Fatness (ocean cycle)
	Evaluation Horizon :	18 months
	Harvest Density :	15 kg/m3
	Evaluation Criteria :	Net Present Value
	Annual Discount Rate :	20%
	Equivalent Monthly Discount Rate :	1.88%
	Current Company Tax rate :	17%

Production Parameters		
	Weight start fattening fish (Wi) (gr.) :	100 gr.
	Weight Harvesting fish (Wf) (gr.) :	5,000 gr.
	Fattening period (months) :	18 m
	Equivalent Growth Rate (SGR%) :	0.71%
	Accumulative Mortality x cycle :	20.0%
	Equivalent Monthly Mortality :	1.23%
	Fish planted number x center :	1,000,000
	Fish harvested number x center :	800,000
	Harvesting Biomass (Ton. x center) :	4,000 Ton.

Economic Parameters		
Revenues	Sales Price ($ x kg) :	US$ 5.0/ kg
Cost	Production Cost ($ x kg) :	US$ 2.8/ kg
	Plant & Distribution Cost ($ x kg) :	US$ 0.8/ kg
	Allocation production cost :	Proportional Fattening period
Investment	Investment in Production Center (K$) :	$ 1,800
	Investment Nominal Assets (% over Fix Assets) :	10%
No Cash Expenses	Useful life Fixed Assets (years) :	3
(Tax purpose)	Useful life Nominal Assets (years) :	5
Terminal Value	Real useful life Fix Assets (months) :	96
	Salvage Value (K$) :	K$ 1,463
	Working capital (K$) :	K$ 10,578
	Book Value (K$) :	K$ 12,040

Annex 4.1
b) Discount rate of Salmon Farming in Chile

Discount Rate for Salmon Farming in Chile

Applying CAPM method

re = rf + β*(rm-rf)

re = discount rate unlevered firm.
rf = relevant risk free rate. Treasury Bill or Bond rate for the same period as the investment.
rf = **5.45%** (BCP 5 years March 2012; Bond 5y in Chilean pesos, Central Bank of Chile)
Source: Central Bank of Chile, 2012
See: http://www.bcentral.cl/estadisticas-economicas/series-indicadores/index_db.htm
file: Tasas_instrumentos_BCCH.xls

rm= market return. I used the market index of Chile, IPSA.
Source: Stock Exchange of Santiago, Chile (Bolsa de Comercio de Santiago Chile, 2012)
See: http://www.bolsadesantiago.com/theme/IndicesBursatiles.aspx?NEMO=IPSA

	Value at	Value at	
	1/2/03	4/23/12	3399 days
IPSA index	999	4,551	356%

Average return per day (day %) = 0.04462%
Market return (annual %) = **17.68%**

βu = unlevered Beta. Grade of risk of unlevered company. Beta of comparable firms in the industry
βeta = 1.16 (Marine Harvest MHG.OL Stock exchange)
Marine Harvest is the largest Salmon Farming company with extensive operations in Chile.
See: http://finance.yahoo.com/q?s=mhg.ol&ql=1
See: http://markets.ft.com/Research/Markets/Tearsheets/Summary?s=MHG:OSL

rf =	5.45%
rm =	17.68%
β =	1.16

re =	**19.6%**	* Discount rate Fish Farming in Chile

Annex 4.2

(a) Cash flow and performance indicators of the salmon farming model (items/months 1-9)

Items/ months	0	1	2	3	4	5	6	7	8	9
Sales Price ($/kg) :		$ 5.5	$ 5.5	$ 5.5	$ 5.5	$ 5.5	$ 5.5	$ 5.5	$ 5.5	$ 5.5
Output (ton.) :		0	0	0	0	0	0	0	0	0
Total Revenues (K$) :		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Production Costs (K$) :		-622	-622	-622	-622	-622	-622	-622	-622	-622
Plant $ Distribution Costs (K$) :		0	0	0	0	0	0	0	0	0
- (Depreciation + Amort.) (K$) :		-53	-53	-53	-53	-53	-53	-53	-53	-53
EBIT (K$) :		**-675**	**-675**	**-675**	**-675**	**-675**	**-675**	**-675**	**-675**	**-675**
TAX (17%) (K$) :		0	0	0	0	0	0	0	0	0
EBIT-TAX (K$) :		**-675**	**-675**	**-675**	**-675**	**-675**	**-675**	**-675**	**-675**	**-675**
+ (Depreciation + Amort.) (K$) :		53	53	53	53	53	53	53	53	53
CAPEX Fix Assets (K$) :	-1,800									
CAPEX Nominal Assets (K$) :	-180									
Working Capital (K$) :	-10,578									
TERMINAL Value (K$) :		0	0	0	0	0	0	0	0	0
FREE CASH FLOW (K$) :	**-12,558**	**-622**	**-622**	**-622**	**-622**	**-622**	**-622**	**-622**	**-622**	**-622**
Accumulated Free Cash Flow (K$) :	-12,558	-13,180	-13,802	-14,424	-15,047	-15,669	-16,291	-16,913	-17,536	-18,158

NPV (20%) K$:	**$ 319**
IRR% (annual) :	**21.5%**

(b) Cash flow and performance indicators of the salmon farming model (items/months 10-18)

Items/ months	10	11	12	13	14	15	16	17	18
Sales Price ($/kg) :	$ 5.5	$ 5.5	$ 5.5	$ 5.5	$ 5.5	$ 5.5	$ 5.5	$ 5.5	$ 5.5
Output (ton.) :	0	0	0	0	0	0	0	0	4,000
Total Revenues (K$) :	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**22,000**
Production Costs (K$) :	-622	-622	-622	-622	-622	-622	-622	-622	-622
Plant $ Distribution Costs (K$) :	0	0	0	0	0	0	0	0	-3,200
- (Depreciation + Amort.) (K$) :	-53	-53	-53	-53	-53	-53	-53	-53	-53
EBIT (K$) :	**-675**	**-675**	**-675**	**-675**	**-675**	**-675**	**-675**	**-675**	**18,125**
TAX (17%) (K$) :	0	0	0	0	0	0	0	0	-1,130
EBIT-TAX (K$) :	**-675**	**-675**	**-675**	**-675**	**-675**	**-675**	**-675**	**-675**	**16,995**
+ (Depreciation + Amort.) (K$) :	53	53	53	53	53	53	53	53	53
CAPEX Fix Assets (K$) :									
CAPEX Nominal Assets (K$) :									
Working Capital (K$) :									
Terminal Value (K$) :	0	0	0	0	0	0	0	0	12,040
FREE CASH FLOW (K$) :	**-622**	**-622**	**-622**	**-622**	**-622**	**-622**	**-622**	**-622**	**29,088**
Accumulated Free Cash Flow (K$) :	-18,780	-19,402	-20,024	-20,647	-21,269	-21,891	-22,513	-23,136	5,953

Annex 4.3

Calculations for determining investment in working capital for the salmon farming model

Calculations for Investment in Working Capital (K$)	1	2	3	4	5	6	7	8	9
Revenues (K$) :	0	0	0	0	0	0	0	0	0
Operational Costs (K$) :	-622	-622	-622	-622	-622	-622	-622	-622	-622
Net (K$) :	-622	-622	-622	-622	-622	-622	-622	-622	-622
Cumulative Operations (K$):	-622	-1,244	-1,867	-2,489	-3,111	-3,733	-4,356	-4,978	-5,600
Inv. In Working Capital (K$) :	**-10,578**								
Working Capital ($ x kilo) :	2.64								

Calculations for Investment in Working Capital (K$)	10	11	12	13	14	15	16	17	18
Revenues (K$) :	0	0	0	0	0	0	0	0	22,000
Operational Costs (K$) :	-622	-622	-622	-622	-622	-622	-622	-622	-3,822
Net (K$) :	-622	-622	-622	-622	-622	-622	-622	-622	18,178
Cumulative Operations (K$):	-6,222	-6,844	-7,467	-8,089	-8,711	-9,333	-9,956	-10,578	7,600

Annex 4.4
Sensitivity analysis of the salmon farming model to determine critical variables

Variables to Sensitize		Unit	Initial Value	dNPV/dx	Impact Ranking
Biomass :	0%	Ton.	4,000 Ton.	3.47%	4
Fattening period :	0%	months	18 months	0.03%	7
Accumulate Mortality :	0%	%	20.0%	-0.92%	6
Sales Price :	0%	$ x kilo	$ 5.5	43.61%	1
Production Costs :	0%	$ x kilo	$ 2.80	-33.84%	2
Plant& Distribution Costs :	0%	$ x kilo	$ 0.80	-6.25%	3
Start-up + Investment :	0%	K$	$ 1,980	-2.80%	5

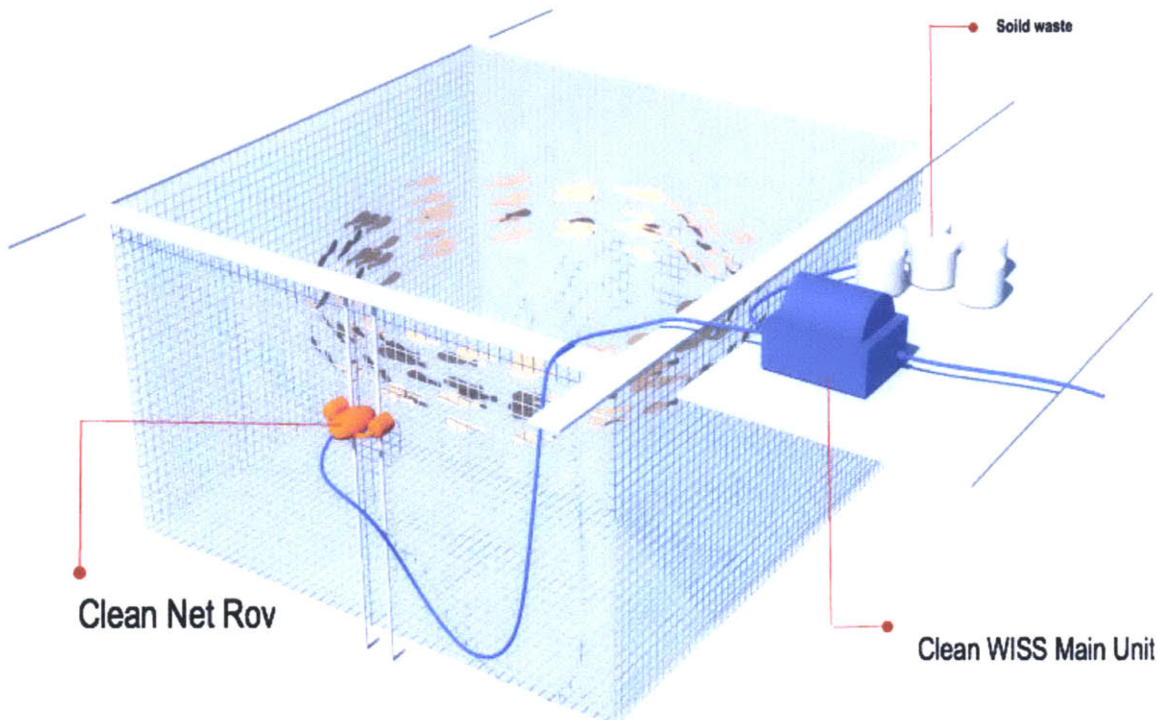
Output Variable	NPV (20%) K$:
NPV (20%) K$:	319

NPV (20%) K$:

Biomass :	-50%	-40%	-30%	-20%	-10%	0%	10%	20%	30%	40%	50%
319	-213	-106	0	106	213	319	425	532	638	744	850
Var.% del VAN	-167%	-133%	-100%	-67%	-33%	0%	33%	67%	100%	133%	167%
Fattening period :	-50%	-40%	-30%	-20%	-10%	0%	10%	20%	30%	40%	50%
319	3,123	2,463	1,824	1,513	906	319	-102	-363	-490	-737	-974
Var.% del VAN	879%	672%	472%	374%	184%	0%	-132%	-214%	-254%	-331%	-405%
Accumulate Mortality :	-50%	-40%	-30%	-20%	-10%	0%	10%	20%	30%	40%	50%
319	452	425	399	372	345	319	292	266	239	213	186
Var.% del VAN	42%	33%	25%	17%	8%	0%	-8%	-17%	-25%	-33%	-42%
Sales Price :	-50%	-40%	-30%	-20%	-10%	0%	10%	20%	30%	40%	50%
319	-7,190	-5,516	-3,848	-2,459	-1,070	319	1,708	3,097	4,486	5,875	7,264
Var.% del VAN	-2354%	-1830%	-1307%	-871%	-436%	0%	436%	871%	1307%	1742%	2178%
Production Costs :	-50%	-40%	-30%	-20%	-10%	0%	10%	20%	30%	40%	50%
319	5,723	4,642	3,561	2,480	1,400	319	-762	-1,843	-2,923	-4,004	-5,085
Var.% del VAN	1694%	1355%	1017%	678%	339%	0%	-339%	-678%	-1017%	-1355%	-1694%
Plant& Distribution Costs :	-50%	-40%	-30%	-20%	-10%	0%	10%	20%	30%	40%	50%
319	1,329	1,127	925	723	521	319	117	-85	-287	-489	-691
Var.% del VAN	317%	253%	190%	127%	63%	0%	-63%	-127%	-190%	-253%	-317%
Startup + Investment :	-50%	-40%	-30%	-20%	-10%	0%	10%	20%	30%	40%	50%
319	734	658	578	495	409	319	225	129	28	-76	-183
Var.% del VAN	130%	106%	81%	55%	28%	0%	-29%	-60%	-91%	-124%	-157%

Annex 5.1

Diagram of the washing in situ system (WISS) in the culture of salmon in Chile



Annex 5.2
Calculations memory for modeling the WISS solution and the traditional system

	Calculation Factors	
Overall	Technological alternatives :	Mutually exclusive
	Methodology :	Present Value
	Evaluation criteria :	Minimum Cost PV
	Annual Discount Rate of the Industry :	20%
	Equivalent Monthly Discount Rate :	1.53%
	Evaluation Horizon :	18 months
	Species:	Atlantic Salmon *(Salmo salar)*
	Phase of Culture :	Fattening
	Unit of study :	One Cage of culture
	Initial fish number in culture x cage :	41,667
	Initial weight culture (gr.) :	100
	Harvest weight (gr.) :	5,000
	Number of days [(a)] :	548
	Number of cages per center :	24
	Fattening period (months) :	18 months

(a) Number of days of culture equivalent to reach commercial size defined as 5,000 grams fish

Production parameters		Nylon Net	Nylon Net + WISS
	Accumulative Mortality x cycle :	20.0%	20.0%
	Mort. equivalent monthly :	1.23%	1.23%
	Number of Fish to harvest :	33,333	33,333
	Growing Rate SGR% x cycle :	0.715%	0.715%
	Harvest weight (gr. x fish) :	5,000	5,000
	Harvest Biomass (Ton. x cage) :	167	167
	Incremental Biomass (Ton. x cage) :	---	0
	Incremental Biomass (%) :	---	0%

		Nylon Net	Nylon Net + WISS
Operating Costs	Installation Fish-Net PCI-1.5" ($/cage) :	$ 3,700	$ 3,700
	Change Fish-Net PCI-1.5" to PCI-2" ($/cage) :	$ 3,200	$ 3,200
	Change Fish-Net PCI-2" to PCI-2" ($/cage) :	$ 3,200	---
	Extraction Fish-Net PSI-1.5" o 2" ($/cage) :	$ 1,000	$ 1,000
	Installation Seal proof-Net LCI-10" ($/cage) :	$ 3,500	$ 3,500
	Change Seal proof-Net LCI a LCI 10" ($/cage) :	$ 3,600	$ 3,600
	Extraction Seal proof-Net 10" ($/cage) :	$ 800	$ 800
	Installation reticulated Seal proof-Net ($/cage):	$ 10,000	$ 10,000
	Maintenance Fish-Net ($ x cage x month) :	$ 180	$ 180
	Maintenance Seal proof-Net ($ x cage x month) :	$ 500	$ 500
	WISS Fish-Net ($/cage) :	---	$ 550
	WISS Seal proof-Net ($/cage) :	---	$ 628
CAPEX	Investment in Net-Culture System ($/cage) :	$ 18,000	$ 18,000
Salvage Value	Real useful life (months) :	48	48
	Salvage Value end of culture ($) :	$ 11,250	$ 11,250

Annex 5.3
Programming net-culture management, traditional system, and WISS

II. Programming net-culture management considering traditional net-system and washing in situ sys

Parameters

Specie :	*Atlantic Salmon (Salmo salar)*
Unit of study :	One Cage of culture
Phase of Culture :	Fattening
Fattening period :	18 months

Nomenclature:

PCI-1.5 : 1.5" Fish-net with antifouling paint
PCI-2 : 2" Fish-net with antifouling paint
PSI-2 : 2" Fish-net WITHOUT antifouling
LCI-10 : 10" Sealproof-net with antifouling paint
LSI-10 : 10" Sealproof-net WITHOUT antifouling paint

		N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A
# Month	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
TRADITIONAL NYLON NET	INSTALLATION				CHANGES			CHANGES				CHANGES			CHANGES				EXTRACTION
Fish-net	PCI-1,5				PCI-2			PCI-2				PCI-2			PCI-2				PCI-2
Sealproof-net	LCI-10					LCI-10					LCI-10				LCI-10				LCI-10

# Month	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
NET + WASHING IN SITU	INSTALLATION				CHANGES														EXTRACTION
Fish-net	PCI-1,5				PCI-2														PCI-2
Washing in situ Fish-net					Washing in situ →													→	
Sealproof-net	LCI-10				Washing in situ →														→ LCI-10

Annex 5.4
Expenses Cash Flow for traditional net management system

A. TRADITIONAL NYLON-NET

	Month	0	1	2	3	4	5	6	7	8	9
FISIC UNITS (quantity)											
Change PCI-2" to PCI-2"	qty.								1		
Change Seal proof-net LCI a LCI 10"	qty.						1				
CURRENCY UNITS ($)	$/cage/op										
Change PCI-2" to PCI-2"	$ 3,200	0	0	0	0	0	0	0	3,200	0	0
Change Seal proof-net LCI a LCI 10"	$ 3,600	0	0	0	0	0	3,600	0	0	0	0
TOTAL DIFFERENTIAL OPERATING COST $:		**0**	**0**	**0**	**0**	**0**	**3,600**	**0**	**3,200**	**0**	**0**

Note: Projected cost based on one culture cage

	Month	10	11	12	13	14	15	16	17	18
FISIC UNITS (quantity)										
Change PCI-2" to PCI-2"	qty.		1			1				
Change Seal proof-net LCI a LCI 10"	qty.	1				1				
CURRENCY UNITS ($)	$/cage/op									
Change PCI-2" to PCI-2"	$ 3,200	0	3,200	0	0	3,200	0	0	0	0
Change Seal proof-net LCI a LCI 10"	$ 3,600	3,600	0	0	0	3,600	0	0	0	0
TOTAL DIFFERENTIAL OPERATING COST $:		**3,600**	**3,200**	**0**	**0**	**6,800**	**0**	**0**	**0**	**0**

	PV of COSTS (20%) $
CPV Mngmt Fish-Net (PV$/cage/cycle) :	**$ 8,171**
CPV Mngmt Seal proof-Net (PV$/cage/cycle) :	**$ 9,339**
CPV Mngmt Fish+Seal proof-Net (PV$/cage/cycle) :	**$ 17,511**

Annex 5.5

Cash flow expenses for proposed WISS applied to net management system

B. WISS	D% Cost :	-15%									
	Month		0	1	2	3	4	5	6	7	8	9
FISIC UNITS (quantity)												
Washing Fish-Net PCI-2"	qty.			1	1	1	1	1	1	1	1	1
Washing Seal proof-Net PCI-10"	qty.			1	1	1	1	1	1	1	1	1
CURRENCY UNITS ($)	$/cage/op											
Washing Fish-Net PCI-2"	$ 467.15		0	467	467	467	467	467	467	467	467	467
Washing Seal proof-Net PCI-10"	$ 533.92		0	534	534	534	534	534	534	534	534	534
TOTALOPERATING COST $:			**0**	**1,001**	**1,001**	**1,001**	**1,001**	**1,001**	**1,001**	**1,001**	**1,001**	**1,001**

Note: Costs projected considering one culture cage as unit of study

	Month	10	11	12	13	14	15	16	17	18
FISIC UNITS (quantity)										
Washing Fish-Net PCI-2"	qty.	1	1	1	1	1	1	1	1	
Washing Seal proof-Net PCI-10"	qty.	1	1	1	1	1	1	1	1	
CURRENCY UNITS ($)	$/cage/op									
Washing Fish-Net PCI-2"	$ 467.15	467	467	467	467	467	467	467	467	0
Washing Seal proof-Net PCI-10"	$ 533.92	534	534	534	534	534	534	534	534	0
TOTALOPERATING COST $:		**1,001**	**1,001**	**1,001**	**1,001**	**1,001**	**1,001**	**1,001**	**1,001**	**0**

	PV of COSTS (20%) $
CPV Mngmt Fish-Net (PV$/cage/cycle) :	**$ 6,946**
CPV Mngmt Seal proof-Net (PV$/cage/cycle) :	**$ 7,939**
CPV Mngmt Fish+Seal proof-Net (PV$/cage/cycle) :	**$ 14,884**

Annex 5.6
Modeling the WISS technology considering competitive performance and economic results

Modeling new technology economics & performance objectives

	Calculation factors	
Overall	Evaluation Level :	Prefeasibility
	Technology :	Washing in Situ FISH-NET
	Methodology :	Present Value
	Evaluation Horizon :	18 months
	Evaluation Criteria :	Max NPV
	Annual Discount Rate Innovation Project :	**30%**
	Annual Discount Rate Salmon Farming :	20%
	Equivalent Monthly Discount Rate :	1.53%
	Current Company Tax rate :	17%
	Specie :	Atlantic Salmon *(Salmo salar)*
	Unit of study :	One Center of Production
	Cages/Center :	24
	Phase of Culture :	Fattening
	Production cycle (months) :	18 months

Economic Parameters

Revenues	Indifference Price ($/cage/month) :	$549.59
	GOAL Decrease Op. Costs Industry in :	**-15%**
Cost	Contribution Margin Average Op. (%) :	**20%**
	Operation new machine (months/cycle) :	17
Useful Life	Useful life Fix Assets (months) :	36
	Real useful life Fix Assets (months) :	60
Investment	Working Capital (months of Op. cost center) :	2

Annex 6.1

Indifference prices for the WISS solution compared with traditional system for net management

TABLE 5.1 Indifference Tariff WISS solution

	Washing Fish Net	Washing Seal proof Net	Washing Fish + Seal proof Net
Tariff ($/cage/month) :	$ 550	$ 628	$ 1,178
Tariff ($/cage/cycle) :	$9,343	$10,678	$20,021
Tariff ($/m2/month) :	$0.25	$0.10	$0.14
Tariff ($/center/month) :	$13,190	$15,075	$28,265
Tariff (K$/center/cycle) :	K$224	K$256	K$481
Parameters			
N° cage x center :	24		
Operation x Cycle (months) :	17 m		
m2 x Net :	2,232	6,379	8,611

PESOS CH$	Washing Fish Net	Washing Seal proof Net	Washing Fish + Seal proof Net
Tariff (CH K$ x cage x month) :	CH K$275	CH K$314	CH K$589
Tariff (CH K$ x center x cycle) :	CHK$4,671	CHK$5,339	CHK$10,011
Tariff (CH K$ x m2 x month) :	CH$123	CH$49	CH$68
Tariff (CH K$ x center x month) :	CHK$6,595	CHK$7,538	CHK$14,133
Tariff (CH K$ x center x cycle) :	MM$112	MM$128	MM$240

Annex 6.2

Sensitivity analysis for calculating indifference prices
(based on change in traditional system for managing nets in the fattening phase in ocean water)

OUTPUT VARIABLES

	TARIFF $/cage /month	PV COSTS (20%) $/cage/cycle
Washing Fish-Net PCI-2"	549.59	$ 8,171
Washing Sea proof-Net PCI-10"	628.14	$ 9,339

SENSITIVITY ANALYSIS

Traditional System Input

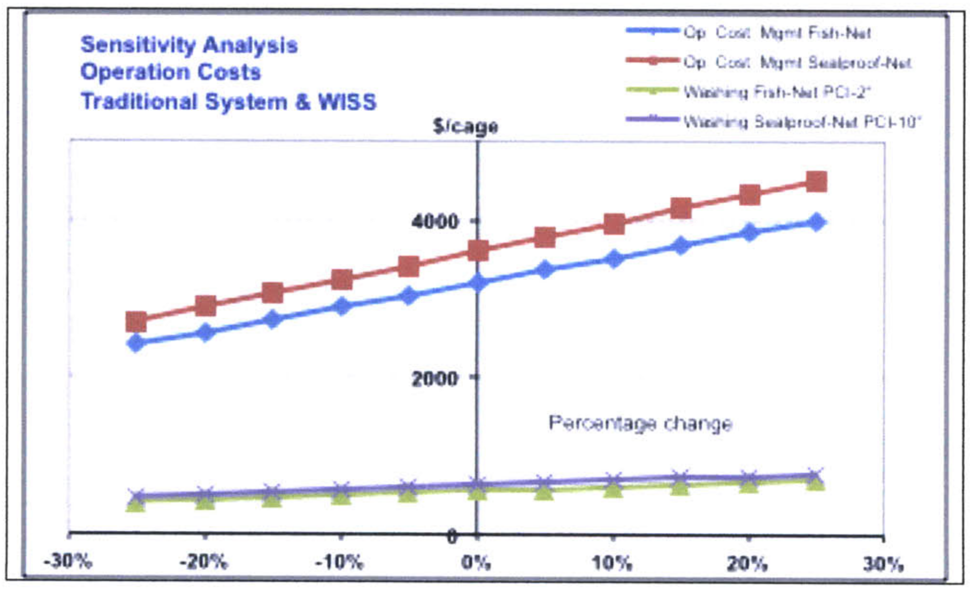
Variables to Sensitize	**Δ**	**Unit**	**Initial Value**	PV COSTS (20%) $
Op. Cost Mgmt Fish-Net	0%	$/cage/op	$3,200	$ 8,171
Op. Cost Mgmt Seal proof-Net	0%	$/cage/op	$3,600	$ 9,339

Annex 6.2 (continued)

Operating cost WISS considering change in op. costs of traditional System (indifference points)

TARIFF $/cage/month

Op. Cost Mgmt Fish-Net	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%	25%
3,200	2400	2560	2720	2880	3040	3200	3360	3520	3680	3840	4000
Op. Cost Mgmt Seal proof-Net	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%	25%
3,600	2700	2880	3060	3240	3420	3600	3780	3960	4140	4320	4500
Washing Fish-Net PCI-2"	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%	25%
550	412	440	467	495	522	550	577	605	632	660	687
Washing Seal proof-Net PCI-10"	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%	25%
628	471	503	534	565	597	628	660	691	722	754	785



Annex 6.3

Results of modeling price of services for implementation of WISS system, and limits of investment considering change in operating cost of the traditional system

Table 5.3. Price of service of the WISS system and value creation respect on the traditional system

	Indifference Price	Reduce Price	Dif. Value
Tariff ($/cage/month) :	549.59	467.15	82.44
PV COSTS (20%) $/cage/cycle :	8,171	6,946	1,226
PV COSTS (20%) $/center/cycle :	196,116	166,698	29,417
Tariff ($/cage/cycle) :	$9,343	$7,942	$1,401
Tariff ($/center/month) :	$13,190	$11,212	$1,979
Tariff (K$/center/cycle) :	K$224	K$191	K$34

SENSITIVITY ANALYSIS

Limited investment in new technology when changing operating cost of traditional system

Traditional System Oper. Cost Mgmt Fish-Net	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%	25%
$/change Net/op. :	2400	2560	2720	2880	3040	3200	3360	3520	3680	3840	4000
Washing Fish-Net	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%	25%
INDIFFERENCE TARIFF ($/cage/month) :	412	440	467	495	522	550	577	605	632	660	687
COMPETITIVE TARIFF ($/cage/month) :	350	374	397	420	444	467	491	514	537	561	584
Tariff (K$/center/cycle) :	K$143	K$152	K$162	K$172	K$181	K$191	K$200	K$210	K$219	K$229	K$238
Operating Cost ($/cage/month) :	280	299	318	336	355	374	392	411	430	448	467
Operating Cost ($/center/month) :	6,727	7,175	7,624	8,072	8,521	8,969	9,418	9,866	10,315	10,763	11,212
Operating Costs ($/center/cycle) :	K$114	K$122	K$130	K$137	K$145	K$152	K$160	K$168	K$175	K$183	K$191
Contribution Margin (%) :	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
IRR % :	30%										
Investment in new tech. w/ change in oper. cost of traditional tech (K$/center) :	K$33.0	K$35.1	K$37.3	K$39.5	K$41.8	K$44.0	K$46.1	K$48.3	K$50.5	K$52.7	K$54.9
Delta % :	-24.95%	-20.16%	-15.14%	-10.14%	-4.93%	0.00%	4.89%	9.90%	14.91%	19.92%	24.93%

Annex 6.4
Cash flow modeling the WISS system

Table I. Cash flow modeling the new technology

Items/ months	0	1	2	3	4	5	6	7	8	9	10
Reduce Price ($/cage/month) :		$ 467.1	$ 467.1	$ 467.1	$ 467.1	$ 467.1	$ 467.1	$ 467.1	$ 467.1	$ 467.1	$ 467.1
Cages/Center :		24	24	24	24	24	24	24	24	24	24
Total Revenues ($) :		**11,212**	**11,212**	**11,212**	**11,212**	**11,212**	**11,212**	**11,212**	**11,212**	**11,212**	**11,212**
Operation Costs ($) :		-8,969	-8,969	-8,969	-8,969	-8,969	-8,969	-8,969	-8,969	-8,969	-8,969
- (Depreciation + Amort.) (K$) :		-1,222	-1,222	-1,222	-1,222	-1,222	-1,222	-1,222	-1,222	-1,222	-1,222
EBT (K$) :		**1,020**	**1,020**	**1,020**	**1,020**	**1,020**	**1,020**	**1,020**	**1,020**	**1,020**	**1,020**
TAX (17%) (K$) :		-173	-173	-173	-173	-173	-173	-173	-173	-173	-173
EAT (K$) :		**847**	**847**	**847**	**847**	**847**	**847**	**847**	**847**	**847**	**847**
+ (Depreciation + Amort.) (K$) :		1,222	1,222	1,222	1,222	1,222	1,222	1,222	1,222	1,222	1,222
Inv. Fix Assets (K$) :	-43,986										
Working Capital (K$) :	-17,938										
Residual Value (K$) :											
CASH FLOW (K$) :	**-61,924**	**2,069**	**2,069**	**2,069**	**2,069**	**2,069**	**2,069**	**2,069**	**2,069**	**2,069**	**2,069**
Accumulated Cash Flow (K$) :	-61,924	-59,855	-57,786	-55,718	-53,649	-51,580	-49,511	-47,442	-45,374	-43,305	-41,236

NPV (20%) K$:	**$ 5,905**
IRR% (annual) :	**30.01%**

Annex 6.4 (continued)

Table I. Cash flow modeling new technology (continued)

Items/ months	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Reduce Price ($/cage/month) :	$ 467.1	$ 467.1	$ 467.1	$ 467.1	$ 467.1	$ 467.1	$ 467.1	$ 0.0
Cages/Center :	24	24	24	24	24	24	24	0
Total Revenues ($) :	**11,212**	**11,212**	**11,212**	**11,212**	**11,212**	**11,212**	**11,212**	**0**
Operating Costs ($) :	-8,969	-8,969	-8,969	-8,969	-8,969	-8,969	-8,969	0
- (Depreciation + Amort.) (K$) :	-1,222	-1,222	-1,222	-1,222	-1,222	-1,222	-1,222	-1,222
EBT (K$) :	**1,020**	**1,020**	**1,020**	**1,020**	**1,020**	**1,020**	**1,020**	**-1,222**
TAX (17%) (K$) :	-173	-173	-173	-173	-173	-173	-173	0
EAT (K$) :	**847**	**847**	**847**	**847**	**847**	**847**	**847**	**-1,222**
+ (Depreciation + Amort.) (K$) :	1,222	1,222	1,222	1,222	1,222	1,222	1,222	1,222
Inv. Fix Assets (K$) :								
Working Capital (K$) :								
Residual Value (K$) :								48,728
CASH FLOW (K$) :	**2,069**	**2,069**	**2,069**	**2,069**	**2,069**	**2,069**	**2,069**	**48,728**
Accumulated Cash Flow (K$) :	-39,167	-37,098	-35,029	-32,961	-30,892	-28,823	-26,754	21,974

Annex 6.5

Limit of investment in new technology required to obtain 30% ROI when operating cost of new technology changes -25% to 25%.

Required investment in new technology when operating cost is changed

Cost Rate of change :	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%	25%
COMPETITIVE TARIFF ($/cage/month) :	$467	$467	$467	$467	$467	$467	$467	$467	$467	$467	$467
Tariff (K$/center/cycle) :	K$191	K$191	K$191	K$191	K$191	K$191	K$191	K$191	K$191	K$191	K$191
Operating Cost ($/cage/month) :	280	299	318	336	355	374	392	411	430	448	467
Operating Costs (K$/center/cycle) :	K$114	K$122	K$130	K$137	K$145	K$152	K$160	K$168	K$175	K$183	K$191
Contribution Margin (%) :	40%	36%	32%	28%	24%	20%	16%	12%	8%	4%	0%
IRR % :	30%										
Investment in new tech. w/ change in oper. cost of new tech (K$/center) :	**K$103.8**	**K$91.8**	**K$79.9**	**K$67.9**	**K$56.0**	**K$44.0**	**K$32.0**	**K$20.1**	**K$8.1**	**-K$3.9**	**-K$15.9**
Delta % :	136%	109%	82%	54%	27%	0%	-27%	-54%	-81%	-109%	-136%
dI/dC :	-5.4351	-5.4295	-5.4374	-5.4412	-5.4619		-5.4405	-5.4403	-5.4333	-5.4402	-5.4475
Delta Inv % :	-27%	-27%	-27%	-27%	-27%		-27%	-27%	-27%	-27%	-27%

Annex 6.6

Tradeoff between investment and operating cost of the WISS system

Tradeoff investment & cost of new technology

dI/dC :	-5.440484504

Operating Cost ($/cage/month) :	374
Operating Costs (K$/center/cycle) :	K$152
Investment in New Technology (K$/center) :	K$44.0

Input= $I --> $Cf

Final Investment (K$/center) :	K$56.0
Δ% I :	27.3%
Δ% C :	-5.01%
Final Cost (CF) ($/cage/month) :	355
Operating costs (K$/center/cycle) :	K$145

Input %C --> $I

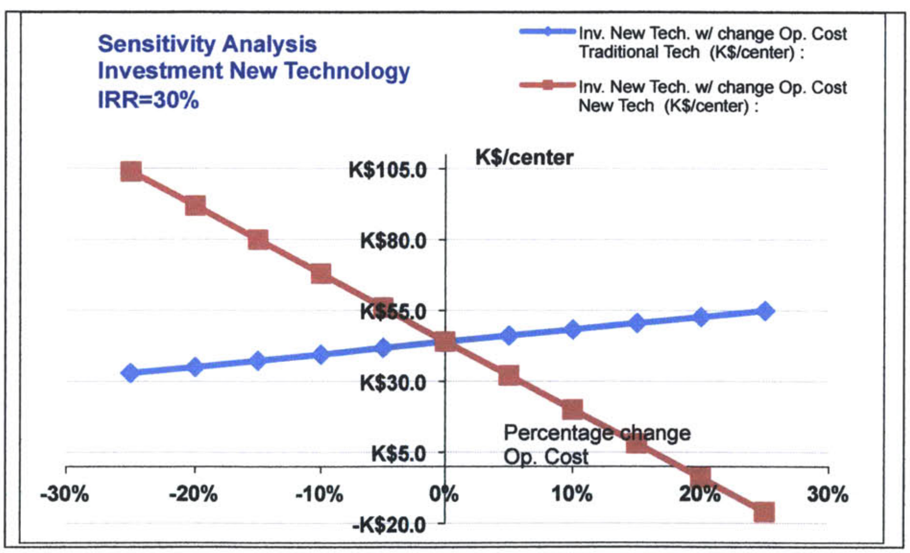
Δ% C :	-5.00%
Δ% I :	27.2%
Final Investment (K$/center) :	K$56.0

Input= %I --> %C

Δ% I :	27.0%
Δ% C :	-4.96%

Input= %C --> %I

Δ% C :	-1.00%
Δ% I :	5.4%



References

AQUA.cl ; web site focusing in Aquaculture and Salmon Farming in Chile (2012). See: <http://www.aqua.cl>. Statistical information and reports 2005-2012, see: http://www.directorioAQUA.com/contenido/dapel_esalmonidos.php

Brealey, R., S. Myers, and F. Allen. *Principles of Corporate Finance.* 10th edition. New York: McGraw-Hill/Irwin, 2010.

CNIC (*Consejo de Innovación para la Competitividad*) (National Innovation Council for Competitiveness of Chile). See: <http://www.cnic.cl>.

"Desafíos Estratégicos para la Acuicultura." ("Strategic Challenges for Aquaculture sector"). National Innovation Council for Competitiveness of Chile (CNIC). January 2009. See: http://biblioteca.cnic.cl/media/users/3/181868/files/18813/DesafiosEstrategicosAcuicultura.pdf

SalmonChile.cl ; web site Association Salmon Producers of Chile (2012). See: http://www.salmonchile.cl/. Statistical information and files on line, see: http://www.salmonchile.cl/frontend/seccion.asp?contid=969&secid=33&secoldid=33&subsecid=117&pag=1; http://www.salmonchile.cl/frontend/seccion.asp?contid=&secid=3&secoldid=3&subsecid=95&pag=1

SERNAPESCA, National Service of Fisheries of Chile. See: <http://www.sernapesca.cl>.

World Economic Forum. *Global Competitive Report 2009-2010.* Geneva, Switzerland 2009. See: <https://members.weforum.org/pdf/GCR09/GCR20092010fullreport.pdf>.